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WEST INDIAN STARCHES.

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A striking point in connexion with West Indian agriculture—one which cannot fail to attract the attention of students of economic botany—is the large number of starch-producing plants. Throughout the whole of the West Indies the sweet potato, the yam and the tannia or coco are the principal foods of the natives. It is a fact, only too obvious, that starch is the main constituent of the West Indian's diet, and that most of the foods are decidedly lacking in other constituents, more especially the flesh-forming, nitrogenous substances.

In the following pages there is given information relating to a large number of these starchy foods and the plants from which they are obtained: and although the primary object of this paper is to deal with the microscopic characters of the starches, it has been considered advisable to include brief notes as to the sources of the starches which are described.

It will at once be seen from the list of starch plants that these are by no means confined to any particular set of orders or families, but are very widely distributed throughout the vegetable kingdom. At the same time, it will be found that it is to some extent characteristic of certain orders to store up food in the form of starch. This is particularly noticeable in the case of the natural order *Scitamineae*, containing, as it does, arrowroot, tous-les-mois and other cannas, ginger, plantain and banana.

In addition to the ordinary food plants, the list contains a number of plants which serve for feeding purposes in times of scarcity. From several of these latter starch is extracted and eaten like arrowroot by the natives, who know it as 'pap.' As examples may be mentioned the sour sop, the sweet sop

and the mango. In these cases the green, unripe fruits are utilized before the stored starch has been converted into sugar.

In Jamaica, starch for laundry purposes appears to be made almost entirely from the cassava, though corn starch is often used for the finer work : in Barbados, arrowroot from St. Vincent is almost exclusively used for this purpose. There are certain other starches mentioned in this paper, which, it seemed to the writer, might well be utilized for this purpose. A nice, white starch can be prepared, for example, from the wild variety of the tannia or coco (*Colocasia esculenta*), or 'scratch coco' as it is often called. This plant grows in great abundance in some parts of the West Indies ; for instance, in the parish of St. Thomas, Jamaica, especially in the neighbourhood of Morant Bay and Bath, it is extremely common by the road-side. Possibly the fact that inconvenience is caused in the manufacture of starch from this plant on account of the irritating juice it contains would stand in the way of its being widely utilized. Again, at certain seasons of the year a large number of bread-fruits are allowed to rot on the ground. Bread-fruit starch, in a perfectly white, clean form, was found by the writer to be most easily prepared.

STARCH PLANTS ARRANGED ACCORDING TO NATURAL ORDERS.

In the following list of the principal starch plants, arranged according to their natural orders, brief notes are also given as to the botanical characters, cultivation, yield, etc :—

ANONACEAE.

As has already been stated, a kind of arrowroot, known locally as 'pap,' is prepared, especially in times of scarcity,

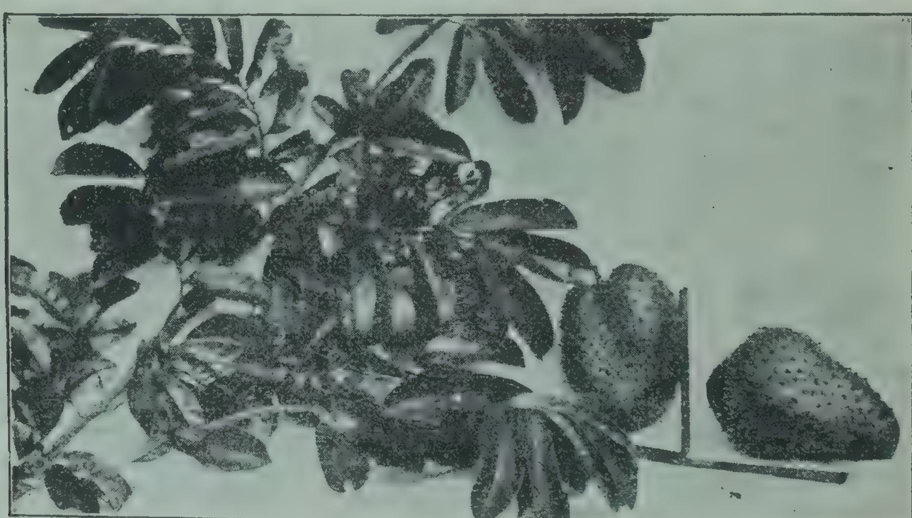

FIG. 1. Fruits and leaves of the Sour sop.
[From the *Annual Report of the Porto Rico Agricultural Experiment Station* for 1902.]

from the unripe fruits of one plant of this family, viz., the Sour-sop (*Anona muricata*).

'The Sour sop is a small tree belonging to the family *Anonaceae.* It grows wild in many parts of the West Indies, where its well-known fruit is much appreciated on account of its pleasant, sub-acid flavour. The tree bears a large, green fruit with rough, prickly skin, which sometimes weighs over 2 lb. It has a soft, juicy, white pulp, in which large black or brown seeds are embedded.' (*Agricultural News*, Vol. II, p. 390.)

It is stated that pap is also prepared from the unripe fruits of the Sweet sop or Sugar apple (*A. squamosa*) and the Custard apple (*A. reticulata*), but the writer has not examined starches from these fruits.

Anacardiaceae.

One of the many uses, to which the widely distributed Mango (*Mangifera indica*) is put, is that of affording a kind of arrowroot. Though but rarely prepared in this dry form, frequent use is made of mango 'pap.' Curiously enough, this can be prepared either from the unripe, fleshy portion (mesocarp) or from the seed or 'kernel.' These two forms are dealt with below.

It is stated in the *Journal of the Jamaica Agricultural Society* (Vol. II, p. 357) that the Secretary had received a sample of starch made from the green mango by a woman in St. Elizabeth. This was referred to the then Island Chemist (Mr. Francis Watts, F.I.C., F.C.S.), who reported as follows:— 'The sample submitted consists of almost pure starch of fairly good colour, though capable of being washed to a somewhat whiter condition. In its properties it is very similar to arrowroot; when boiled with water it produces a jelly of a very similar consistency to that produced by the latter starch. As an article either of diet or of commerce, mango starch will compare very closely with arrowroot: this being so, it is very doubtful whether it can be produced at a price sufficiently low to compete with arrowroot, of which the ordinary brands are now selling in the wholesale markets at prices ranging from 2*d.* to 4*d.* per lb.' (Ibid., p. 407.)

In this connexion the writer's experience in the preparation of mango starch, given under the heading of 'Preparation of starch from the foregoing plants' on p. 15, may be of interest.

Leguminosae.

Starch is present in the seeds of a large number of leguminous plants found in the West Indies. As, however, the proportion of starch is usually small, and starch is, in consequence, never prepared from them, but four examples are considered in this paper. These are the Congo or pigeon pea (*Cajanus indicus*), the common 'red pea' (*Phaseolus vulgaris*), 'Crab's eye' seeds (*Abrus precatorius*), and the Ground nut or Earth nut (*Arachis hypogaea*).

Reference must, however, be made to the Yam bean (*Pachyrhizus tuberosus*), which produces a large, starchy tuber, used for food purposes in times of scarcity.

The following account of this plant was published in the *Agricultural News*, Vol. III, p. 109:—

The yam bean is not particularly common in the West Indies, although plants are to be found in cultivation in several of the islands.

The following description of the plant and its uses is taken from Macfayden's *Flora of Jamaica* (p. 286):—

'Flowers white. Seeds red. The root is formed of a number of simple cord-like fibres, stretching under the surface of the ground, bearing in their course a succession of tubers.

'The beans are poisonous, but the root affords a very plentiful supply of a very wholesome food. The produce of three plants is usually sufficient to fill a bushel basket. The tubers may be either boiled plain, in which state they are a very good substitute for yams or other roots in common use, or they may be submitted to a process similar to arrowroot, and a starch obtained. This starch is of a pure white, and is equal in every respect to arrowroot. To the taste it is very palatable for custards or puddings. Even the trash left after obtaining the starch, and which, in the preparation of arrowroot, is lost, may, when thoroughly dried, be formed into a palatable and wholesome flour.

'A very excellent flour may also be obtained by slicing the tubers, drying them in the sun, and then reducing to a powder.

'This plant is deserving of being more generally cultivated than it has hitherto been. It ought in a great measure to supersede the arrowroot in cultivation. It can be planted at any season of the year and the roots are fit for digging in the course of four or five months; the return is infinitely greater than that from arrowroot, and the proportion of starch also is more abundant, so that it can be brought to market at so cheap a rate as to admit of being employed by calico printers in place of potato starch.'

In an article on this plant in the *Kew Bulletin* (1889, p. 17) reference is made to the use of the young pods as a vegetable, served like French beans, to which, however, they are superior owing to the absence of any fibrous strings. Although the beans are poisonous, the young beans can safely be eaten when cooked.

It is stated in the *Bulletin of the Jamaica Botanical Department* (No. 44, p. 4) that from one seed sown at Hope Gardens five yams were dug weighing altogether 14 ℔.

CUCURBITACEAE.

The only representative of this order among the West Indian starch plants is the Cho-cho (*Sechium edule*). This plant is known by a number of local names, among which may be mentioned 'Christophine,' 'Chayote' and 'Chayota'. It is widely cultivated for the sake of its edible fruit.

It is a climbing plant, its smooth stem being furnished with tendrils. The flowers are yellow, male and female being

found on the same plant. The fruit, which is about 4 inches long, is used as a vegetable, though in places where it is very abundant, it is also much used for feeding stock, especially pigs. It has also a reputation as a milk producer when fed to cows.

The cho-cho bears a large fleshy root which can be cooked and eaten like a yam. It can be severed from the parent plant, which will often go on bearing for six or seven years. According to Simmons in *Tropical Agriculture*, this root contains about 20 per cent. of starch. The following analysis of the root published by Herrera in *La Naturaleza*, is given in Bulletin No. 28, Division of Botany, U. S. Department of Agriculture (*The Chayote: a tropical vegetable*) :—

Water	71·00
Starch	20·00
Resinous material soluble in ether	·20
Sugars	·32
Vegetable albumen	·43
Cellulose	5·60
Extracted material	2·25
Loss	·20
	100·00

'On account of the ease with which it is digested, Herrera advocates the use of the starch of the chayote as a substitute for arrowroot in feeding children and invalids as well as for general purposes.'

Apocynaceae.

This order contains one plant, at least, in which starch is permanently stored, viz., *Echites umbellata*. In Jamaica it is a common weed in pastures and is known as 'nightshade.' It is said to be a deadly poison, and although stock usually give it a wide berth, accidents have been known to occur through animals eating the plant when it has been disguised in some way. It appears to be understood that the swollen roots of this plant can be used for food purposes, provided the poison is thoroughly washed out, but nevertheless it is scarcely ever used. It would seem advisable, however, that analysts should be familiar with the structure of the grains of this starch, and a description is, therefore, included in this paper.

Convolvulaceae.

This order contains the important genus *Ipomoea*. In Jamaica there are about thirty native species, a number of which are cultivated on account of their beautiful flowers. The sweet potato (*Ipomoea Batatas*), however, is cultivated for the sake of its tuberous roots, while starch is prepared from several other species.

In habit they are generally climbers, as for example, *I. Horsfalliae*, a common house 'creeper' with its fine crimson flowers. Some like the sweet potato have trailing stems. The

flower usually has a tubular or bell-shaped corolla of various shades.

Among the species of the genus *Ipomoea* whose starches are described in the following pages are :—

I. Batatas (sweet potato); a plant with herbaceous trailing stem and rose-coloured flowers having a purple centre. The stem sends out roots at the node wherever it is in contact with moist earth, and 'tubers' may be produced at these points as well as on the original root.

I. Horsfalliae is a species found in both the wild and the cultivated state, its rich crimson flowers being very handsome. The plant is a creeper and bears large swollen roots that can be severed without disturbing the plant. From these starch is prepared by the peasants in Jamaica in times of scarcity.

I. fastigiata (called 'wild potato' in Jamaica) is a wild twining species, especially common in the limestone districts.

The only species commonly cultivated is the sweet potato (*I. Batatas*). In the West Indies it is usually propagated by cuttings from the 'vines.' With good cultivation the yield is said to be from 4 to 5 tons per acre. Under exceptionally favourable circumstances, a yield of 7 tons to the acre has been obtained.

FIG. 2. Ipomoea Batatas.
[From *Dictionary of Gardening.*]

The percentage of starch in the roots varies from 20 to 26. Duggar in *Sweet Potatos: Culture and Uses* (Farmers' Bulletin No. 26, United States Department of Agriculture) gives the average composition of seven varieties calculated from analyses of roots grown in three or four States, which he summarizes as follows :—

Water	69·32	to	73·11
Ash	1·09	,,	1·29
Protein	1·38	,,	2·47
Fibre	0·86	,,	1·23
Nitrogen free extract (starch, etc.)	22·73	,,	28·46
Fat	0·43	,,	0·85

NYCTAGINEAE.

An enlarged root, containing considerable quantities of starch, is found on the common, roadside plant, called in

Jamaica 'Four o' clock' (*Myrabilis dichotoma*). This plant obtains its popular name from the fact that the flowers do not open until the sun has left them.

POLYGONACEAE.

The large-growing form of the popular creeper, known in the West Indies as 'Pink Coralita' (*Antigonon insignis*), has tuberous roots resembling those of cassava.

EUPHORBIACEAE.

This order contains one of the most important sources of commercial starch, viz., cassava. There are two forms of cassava, known respectively as 'sweet' cassava (*Manihot Aipi*) and 'bitter' cassava (*Manihot utilissima*). Of these the latter contains considerable proportions of prussic acid; while sweet cassava is frequently supposed to be free from this poison. It should, however, be pointed out that this distinction is not altogether to be relied upon. It has been demonstrated by Francis and afterwards by Carmody, in Trinidad, and by Cousins, in Jamaica, and others that the so-called 'sweet' cassava frequently contains a considerable quantity of prussic acid. Consequently, great care is necessary in using these plants for food purposes. As stated in the *Agricultural News*, Vol. I, p. 5: 'From their investigations it appears that "sweet" cassava not only contains the poisonous prussic acid, but contains nearly as much as bitter cassava, and that by mere chemical analysis it would be impossible to distinguish between the two. Professor Carmody was able to show that whilst in bitter cassava the prussic acid is distributed more or less uniformly throughout the tissues of the root, in the sweet cassava it is located in the skin and outer portion of the rind.'

For purposes of starch extraction the various varieties of bitter cassava are usually preferred on account of their containing a larger percentage of starch. Moreover, a valuable by-product is obtained in the manufacture of starch from bitter cassava by concentrating the extracted juice and dissipating the poison by boiling. This by-product is known as 'cassareep' and forms the basis of many well-known sauces. Cassava contains from 20 to 30 per cent. of starch.

Writing on 'Jamaica Cassava' in the *Bulletin of the Jamaica Department of Agriculture* for February 1904, Mr. H. H. Cousins says: 'The demand for cassava starch of high quality for dressing Manchester goods has recently been impressed upon us by the visit of a prominent representative of the industry in Manchester. If Jamaica can produce a high-quality cassava starch, free from fibre, grit and dirt, and also free from the organic acids of fermentation which so readily arise when cassava tubers are allowed to stand, or the manufacture is carried out in a dilatory and imperfect manner, there is an assured market for all we can produce and at a remunerative price.' The announcement as to the result of a trial shipment of cassava starch from Jamaica, published in the *Agricultural News* (Vol. III, p. 137), is likely to give an impetus to the cultivation of cassava in the West Indies for the manufacture of starch.

A complete account of this plant and its cultivation will be found in Farmers' Bulletin No. 167, U.S. Department of Agriculture; while Bulletin No. 58 of the Division of Chemistry (*The manufacture of starch from Potatos and Cassava*) gives valuable information in relation to the suitability of cassava as a source of starch.

URTICACEAE.

In the natural order *Urticaceae* are found several plants bearing starchy fruits or seeds. The Bread-fruit (*Artocarpus incisa*) and the Jack-fruit (*A. integrifolia*) are dealt with in this paper. The well-known bread-fruit tree produces an abundance of large, starchy fruits which are usually cooked and eaten as a vegetable. In some islands, however, a large number of fruits are allowed to drop to the ground and rot. As suggested elsewhere, this waste might perhaps be prevented by preparing the beautifully white starch for commercial purposes.

'The following analysis of the bread-fruit is recorded in the *Experiment Station Record*, Vol. XII, p. 1,076 :—

Water	46·21	per cent.
Protein	2·34	,, ,,
Fat	0·40	,, ,,
Starch	41·42	,, ,,
Crude fibre	4·20	,, ,,
Ash	1·78	,, ,,
Undetermined	3·65	,, ,,

'In comparison with the sweet potato and yam (which agree very closely with one another in their chemical composition), the bread-fruit contains 25 to 30 per cent. less water, about 25 per cent. more starch and a distinctly higher proportion of protein or nitrogenous matter. Expressed in other words, whilst 1 ℔. weight of sweet potato or yam contains about 12 oz. of water and 2 oz. of starch, 1 ℔. of bread-fruit contains about 6½ oz. of starch and only 7 oz. of water. Although superior as a food stuff, so far as chemical composition is concerned, the presence of over 4 per cent. of fibrous matter in the bread-fruit is a point in which it compares unfavourably with the sweet potato and yam.' (*Agricultural News*, Vol. I, p. 40.)

The following account of the jack-fruit tree has appeared in the *Agricultural News* (Vol. II, p. 342) :—

The Jack-fruit (*Artocarpus integrifolia*) is a large tree of East Indian origin, closely related to the bread-fruit (*Artocarpus incisa*). It is common throughout the West Indies where, as in the East, the fruit is much esteemed among the natives.

The large, collective fruit is, like the pine-apple, made up of an aggregation of fruits (fig. 3). It varies in size from 12 to 18 inches and sometimes weighs as much as 60 ℔. The individual fruits, which are known as flakes, consist of a seed enveloped in a sticky, pulpy mass having a strong odour. The number of these flakes varies from fifty to eighty. Though much appreciated by the natives, this fruit is rarely eaten by Europeans on account of its unpleasant odour.

The seed, when roasted, is eaten as an article of food, and is said to resemble chestnuts. A writer in the *Indian Agriculturist* says: 'I believe it contains a very large percentage of starch, and as such could be utilized in a variety of forms. If these seeds be taken to weigh $\frac{1}{3}$ oz. each, one fruit will give us 30 oz. of flour, and twenty fruits, the produce of one tree, 600 oz. or 37 lb. of flour.' (Watts in *Dictionary of Economic Products of India.*)

FIG. 3. Artocarpus integrifolia.
Showing fruit and leaves.
[From *Kew Guide.*]

The jack-fruit yields a valuable, fairly hard timber much used for making furniture.

The heartwood is of a light, yellowish colour when freshly cut, but darkens considerably on exposure. It possesses a beautiful grain and is capable of taking a high polish.

The wood also yields a yellowish colouring matter used for dyeing clothes. From the bark, a dark gum is obtained, while the juice of the fruit yields a caoutchouc-like substance.

The tree affords excellent shade for stock in pastures, and is recommended by some as a suitable shade tree for coffee, but this favourable opinion is not uniformly held.

AROIDEAE.

One of the most commonly occurring food plants in the West Indies is *Colocasia esculenta*, of which the following description appeared in the *Agricultural News*, Vol. II, p. 358: —

This plant, whose botanical name is *Colocasia esculenta*, is known by a variety of names. The name, tannia, is probably the one most generally used, though the spelling of it varies considerably —'tanier,' 'tannier,' 'tania,' all being found. In Jamaica yet another name — 'coco' — is given to the plant; while in the East it is called 'taro.'

FIG. 4. Colocasia esculenta.
[From *Dictionary of Gardening.*]

Colocasia esculenta, belonging to the natural order *Aroideae*, is a stemless perennial herb with large arrow-

headed leaves. It is cultivated for the sake of its starchy root-stock, which is frequently large and thick. As a food crop this plant occupies an important place in the West Indian Islands, its tubers being one of the principal articles of diet among the poorer classes. In addition to the rhizomes, the young leaves are eaten as a vegetable.

The cultivation of tannias is of a very simple nature, being similar in most respects to that of yams. In good land, that has been well prepared, large crops can be obtained. At the Agricultural School in St. Vincent, $4{,}336\frac{1}{2}$ lb., valued at £13 12*s.* 11*d.*, were dug from $\frac{1}{2}$ acre.

In these islands this plant has another important use, namely, as a shade plant. It is particularly adapted for shading young cacao plants, and has been similarly used for coffee.

Another plant, usually considered to be a variety of *Colocasia esculenta,* is that known as 'wild tannia' or 'scratch coco.' This plant, it seems to the writer, might well be made use of as a source of starch. It is very abundant in Jamaica, and is, in fact, regarded in some parts as a troublesome weed. The reason for the common name, 'scratch coco', became at once apparent to the writer when he extracted starch from its rhizomes.

Gramineae.

Two members of the grass family are included in this list, viz., Corn or Maize (*Zea Mays*) and Guinea corn (*Sorghum vulgare*). Both these plants are commonly cultivated throughout the West Indies and no description of them or of their cultivation is necessary.

The cultivation of maize has attained huge proportions in the United States. In the *Yearbook of the U. S. Department of Agriculture* it is stated that the corn crop of 1900 was 2,105,103,000 bushels, out of a total production (for the world) of 2,822,900,000 bushels.

Dioscoreae.

This is the order of the yam plants. The *Dioscoreae* are said to have been introduced into the West Indies from Africa and Asia. They are now widely distributed throughout the West Indies. The plants are herbaceous with tubers or rhizomes. Their slender stems, often measuring 20 feet in length, hold themselves up by twining around some support. The rotation is towards the left, though there is one curious exception, the Indian yam or 'yampie' (*Dioscorea trifida*), which turns always to the right.

The tubers vary considerably in size and colour. Those produced by *D. trifida* are about the size of small potatos, while those of other species often weigh 30 to 40 lb. or even more, and measure as much as 3 to 4 feet in length. There is a very large number of yams known to cultivators in the West Indies, but they all appear to be varieties of three or four species.

As pointed out by Mr. Hart in the Trinidad *Bulletin of Miscellaneous Information* (Vol. II, p. 206), the nomenclature of

the Dioscoreas is anything but clear. While giving the following list of yams, Mr. Hart states: 'The botanical names here given are those to which it is believed the various species should be referred, but are still given with some diffidence and only as material for better identification':—

1. *Dioscorea alata*, L.—Negro yam, Barbados yam, White yam.
2. *D. sativa*, L.—Yellow yam.
3. *D. lutea*, Mey—Afou yam.
4. *D. galabra*, Roxb. } —Chinese yam.
   D. batatas, Decas }
5. *D. trifida*, L.—Cush-cush or Indian yam.
6. *D. bulbifera*, L.—'Cut-and-throw-away' yam.
7. *D. triphylla*, L.
8. *D. polygonoides*, H.B.K.
9. *D. Kegeliana*, Grisb.

The yams, whose starches are here described, are those known in Jamaica as Negro yam, Yellow yam, Lucea yam, White yam, White flour yam, and the yampie or Indian yam (*D. trifida*).

The yam is one of the chief foods of the negro and is considered more nutritious than the English potato. Church in his *Food* gives the following average composition :—

Water	79·6
Albuminoids	2·2
Starch	15·3
Fat	0·5
Cellulose	0·9
Mineral matter	1·5

The cultivation of yams is of the simplest nature. The soil is merely loosened with a hoe before planting, the soil being afterwards drawn up into a 'hill'. In Jamaica and Trinidad a pole, about 8 feet long, is placed in the ground for the plant to twine around; in Barbados, however, the plants simply trail along the ground.

The usual method of propagation, as practised by the peasant, is as follows: The tubers are removed in such a way as to leave the top with the 'vines' attached, which are returned to the soil and moulded up. After about three months, another tuber is formed; this is known as the 'head' and is used for propagating purposes. But the yam can be propagated like the Irish potato, i.e., by cutting up the tuber into a number of pieces, each of which will produce a plant.

An acre will yield from 4 to 5 tons of tubers per annum.

Scitamineae

As already mentioned, this order contains a large number of starch-yielding plants, viz., Tous-les-mois (*Canna edulis*), Indian shot (*C. indica*), Arrowroot (*Maranta arundinacea*), Ginger (*Zingiber officinale*), and the tribe *Museae*. These plants are all cultivated for the sake of their starchy rhizomes, by which, too, they are usually propagated.

Arrowroot is cultivated extensively in the West Indies, notably in St. Vincent. But Bermuda arrowroot is usually

considered of a higher quality and commands a higher price in the market. In growing arrowroot the preparation of the land is of great importance, the yield being much greater where it is grown under high cultivation. Dr. Nicholls states in his *Tropical Agriculture*: 'The rhizomes contain 20 per cent., or even more, of starch; but, owing to the rude processes of manufacture usually employed to separate the fecula, it is seldom that more than 15 per cent. is got and this would give about 7 cwt. of prepared arrowroot to the acre. But with high cultivation, on rich soil, much larger returns may be looked for. Indeed, in Natal, as much as 1 ton of arrowroot has been made from the rhizomes grown on an acre of ground'.

The following interesting account of the preparation of arrowroot is also taken from Dr. Nicholls' work :—

'The rhizomes having been dug up and washed they are pared with sharp knives so that every portion of the outside skin is removed; and, at the same time, all unsound portions are cut away. The skin contains a resinous substance which would discolour the arrowroot and give it a disagreeable flavour; it is necessary, therefore, that great attention be given to the paring of the rhizomes. After the skin is removed, a second washing is necessary; and then, in order to get out the starch, the rhizomes are to be reduced to a pulp. This may be effected in three ways, namely, (1) by pounding them in wooden mortars; (2) by passing them between the rollers of a mill; (3) by pressing them against a rapidly revolving wheel covered with rough tin like a nutmeg grater—which tears the mass to pieces. In places where arrowroot is cultivated on a moderately large scale, the last mentioned pulping process is the best, for the grating mill can be made at very little expense. The next thing to do is to mix the pulp thoroughly with good clear water, and then to pass the whole through a fine sieve which separates the fibrous substance and permits the fecula to be carried off with the water through the meshes of the sieve. The fibrous refuse is thoroughly squeezed to force out any of the starch entangled in it, and it is then thrown away, or, preferably, used as manure for the next crop. The water and the starch are run into cisterns or tubs and allowed to settle, when, after a time all the starch will subside to the bottom and the water can be drawn off. The fecula is then stirred up with fresh water, passed through a second sieve of a finer mesh, which may be of brass wire or muslin, and allowed to settle as before, the supernatant fluid being drawn off when all the starch has fallen to the bottom. This process may be repeated several times, or until the water appears perfectly clear over the starch. The object of the several washings is to remove everything from the pulp but the starch, which, in its pure state, is the arrowroot of commerce. After the last washing the water is drawn off, and the pasty starch is taken out of the tubs or vats and put on trays with calico bottoms to drain and to dry, the drying process being usually effected in the sun or in sheds, the sides of which are left open or enclosed simply with galvanized wire netting to allow a free circulation of air. In Bermuda, it is calculated, according to Simmonds, that "4 barrels of peeled

and cleaned rhizomes will yield in good season about 100 lb. of good arrowroot, and will take from 5 to 6 puncheons of clear soft or tank water; it will be about twenty-four hours in the water from the time of grinding till it is upon the cloths or drainers". The arrowroot will take about three or four days to dry properly; but the hotter the sun or the drier the air and the more quickly the product is desiccated, the whiter will be its colour and the better its quality. After it is dried the starch will be in cakes which will have to be broken up into small lumps before it is packed.'

Tous-les-mois is cultivated in much the same manner as arrowroot, and the starch is prepared by a similar method. Tous-les-mois 'arrowroot' is of considerable value as a food for infants and invalids, the starch being very readily soluble in boiling water. It is stated in the *Journal of the Jamaica Agricultural Society* that in New South Wales 33 tons of tubers were obtained on 1 acre, yielding 3½ tons of starch. This plant, and also the Indian shot (*C. indica*) are cultivated in Jamaica under the unfortunate name of 'tapioca'; and starch is prepared from them.

Ginger: The structure of the starch grains of ginger will be discussed in the following pages, but as this plant is never grown for the sake of its starch, no further mention need be made of it here.

MUSEAE.

The starch plants in this tribe are the Banana (*Musa sapientum*) and the Plantain (*M. sapientum*, var. *paradisiaca*). The plants are cultivated almost everywhere in the tropics where they form important articles of food.

Many attempts have in recent years been made to develop a trade in banana flour and banana meal. These articles are credited with considerable dietetic qualities, both on account of their nutritive value and their ready digestibility.

The following analysis of fresh peeled bananas is taken from Professor Church's *Food*:—

Water	73·9
Albuminoids	1·7
Sugar and pectose ...	22·8
Fat	0·6
Cellulose...	0·2
Mineral matter	0·8

If this be compared with the following analysis of fresh, green (unripe) bananas, published by Messrs. Harrison and Jenman (*Report on Agricultural work in the Botanic Gardens, British Guiana*, for 1890), it will be seen that the composition of the fruit at different stages of maturity varies very considerably. As stated by Dr. Warden in the *Dictionary of Economic Products of India* (Vol. V, p. 301): 'The green fruit contains over 12 per cent. of starch, which disappears as the fruit ripens':—

Water	...	...	75·11
Fat	...	...	·18
Sucrose	...	...	
Glucose	...	...	·29
Starch	...	...	11·11
Albuminoids	...	...	1·35
Gums, etc.	...	...	·36
Digestible fibre	...	...	10·07
Woody fibre	...	...	·66
Ash	...	...	·87

The composition of banana and plaintain fruits is also dealt with in an article in the *Kew Bulletin* (1894, pp. 305-10), where the following results of Professor Church's analyses of samples of banana meal, (a) from Jamaica and (b) from Surinam, are given :—

	(a)	(b)
Water	15·5	14·3
Albuminoids	2·5	2·3
Starch, sugar, gum, etc.	77·7	79·5
Oil	1·0	·7
Fibre	·7	·9
Ash	2·6	2·3

'In the above samples starch is more abundant than sugar; the proportions of the latter increase as the fruit ripens.'

In reference to the composition of these fruits, Messrs. Harrison and Jenman make the following statement in the report referred to above :—

'Though the food elements in the banana vary from those of the plantain, the sum total of them is much the same. The plantain is decidedly richer in starch and glucose, while the banana excels in albuminoids and digestible fibre. The advantage of value is with the plantain.

'The following analyses of the common plantain, fresh and dried respectively, are closely representative of the character of all varieties. Plantains are essentially a starchy food, deficient in albuminoids and fat :—

	Fresh pulp.	Flour from dried pulp.
Water	62·86	11·80
Fats...	·44	1·05
Albuminoids... ...	1·58	3·75
Glucose	2·25	5·34
Starch	22·16	52·64
Tannin, gum, etc. ...	·50	1·20
Digestible fibre ...	9·01	21·37
Indigestible fibre ...	·40	·95
Ash	·80	1·90

PREPARATION OF STARCH FROM THE FOREGOING PLANTS.

The following brief notes on the preparation of starch from the foregoing plants will be of interest as indicating the possibilities of the uses of these plants as starch producers on a commercial scale.

In order to have absolutely authentic specimens of the starches to be described, the writer personally prepared samples from all of the plants in the above list. He is, however, indebted to Mr. Oscar A. M. Feurtado, of Belle Vue, Jamaica, for samples of banana starch. Mr. Feurtado has for some time been engaged in the commercial preparation of banana meal.

In preparing starch from roots and tubers, the following was the method adopted :—The tubers were first well washed and their skins removed; they were then grated with an ordinary kitchen grater, the grated material being next placed in a muslin bag and squeezed with the hand in a vessel of clean water. The starch was thereby roughly extracted. It settled to the bottom of the vessel on being allowed to stand. The water was thereupon decanted and the sediment stirred up with fresh, clean water. This washing process was repeated several times until the starch settled quite clean: this was afterwards dried in the sun in shallow dishes.

In the case of seeds, the grater was replaced by a small coffee mill, the remainder of the operation being identical with that adopted for roots and tubers.

It will be seen from the following notes that there was a great variation in the ease with which the starches could be extracted. Some were difficult to grate; in other cases, the difficulty was to squeeze out the starch, seemingly on account of the presence of mucilaginous matter which caused the mass to become very stiff. Again, probably for the same reason, the starch of some of the plants took a long time to settle; and frequently the fermentation, which often took place, rendered matters still more difficult. Such points as these would have to be taken into consideration in determining what starches could be extracted on a commercial scale :—

Sour sop: On account of the large number of seeds in the fruit and the readiness with which the fruit stains, it is extremely difficult to prepare starch from this fruit. Moreover, the starchy liquid undergoes fermentation so quickly, that it is difficult to wash the starch. Hence, the latter is nearly always of a bad colour.

Mango: Practically the same difficulties occur here, but it is possible by very careful washing to get a much whiter starch.

Red pea and Pigeon pea: There is no difficulty in preparing a nice, white starch from these seeds, and the same may be said of the Crab's eye beans (*Abrus precatorius*).

Ground nut: The difficulty in this case is to get rid of the oil. The amount of starch is small and it can be obtained without much difficulty from the 'meal.' It is only included

in this paper on account of its exhibiting characters entirely different from those of ordinary leguminous starches.

Yam bean : The preparation of starch from the yam bean is a very simple matter. The root, which is of a very watery nature, is easily grated, and there is no mucilaginous matter to interfere with the squeezing process. The starch settles rather slowly, but a nice, white product can be obtained without much washing. This is of interest as adding weight to Macfayden's recommendation (see p. 4) that this plant should be grown as a source of starch.

Starch was also obtained from the seeds of the yam bean. The notes given above, for ground nut starch, apply also in this case.

Cho-cho : A beautifully clean, white starch can be obtained from the cho-cho roots without the slightest difficulty.

Nightshade : When once the tubers have been grated, it is a simple matter to prepare a nice, white starch. The squeezing operation gives no trouble and the starch settles readily. The tubers, however, are small and of irregular shape, which makes it difficult to scrape and grate them.

Pink Coralita : Starch can be extracted from the tuberous roots of this plant without any difficulty. The roots being dry, they are readily grated, and there is no mucilaginous matter to hinder the succeeding operations.

Sweet potato : There is no difficulty in preparing starch from the sweet potato root, nor from those of the other *Ipomoeae*. The starch washes well and when dry is quite white.

Cassava : The same remarks apply to both bitter and sweet varieties of the cassava.

Bread-fruit : The starch separates freely and can be obtained in a perfectly white condition.

Jack-fruit : In this case great difficulty is experienced. The individual seeds have to be grated. They stain very readily and fermentation soon sets up. These difficulties make it almost impossible to obtain a clean, white starch.

Arrowroot, Cannas and Ginger : Very little difficulty was experienced in the case of these, except that the starch requires several washings before it is entirely free from dirt. On account of the knotted and fibrous nature of some of the rhizomes, they are not easy to scrape.

Banana : It is extremely troublesome, on account both of the readiness with which the fruit stains and of the rapid fermentation, to prepare banana starch. The writer was unable, even after several attempts, to get a really white starch. Mr. Feurtado, who furnished samples, states that he has always experienced similar difficulties.

Plantain : Strange to say, the plantain gave far less trouble, and the starch obtained from it was fairly white.

Yams : With all the varieties of yams difficulty was experienced on account of the presence of mucilaginous matter. The most difficult, in this respect, was the 'white' yam ; the 'negro' variety gave the least trouble. But although it is so

difficult to squeeze out the starch, the latter settles readily, and the result is as white a starch as can be desired.

Tannia or Coco: There appears to be a large amount of mucilaginous matter in the edible variety, and this makes the squeezing process slow and tedious. The starch settles readily, however, and is fairly white. In digging tubers for starch preparation care would have to be taken to avoid injuring the tubers, as where cut the surfaces become much discoloured, and this adds to the difficulty of getting a white starch.

In the case, however, of the wild tannia or 'scratch coco,' starch extraction is very easy. There appears to be far less gummy matter and consequently the starch comes through the muslin quite readily. Scarcely any washing is required to give a perfectly white starch.

MICROSCOPIC CHARACTERS OF STARCH GRAINS.

(1) Identification and Classification of Starches.

The examination of starch grains has always been a popular study with microscopists, probably ever since the compound microscope came into use. In consequence, it has long been known that starches of different origin show distinct and definite characters, and that this fact renders it possible to determine from what plant any particular starch has been prepared. This has been found to be of great service in detecting adulterations: a common instance of which is to be found in the detection of the adulteration of arrowroot with potato starch. The larger size of the potato grain, the greater distinctness of the concentric lines, as well as the position of the hilum and other characteristics, make it a simple matter to distinguish the two starches when examined microscopically.

Examination by polarized light is found of great assistance in identifying starches. Blyth recommends it in conjunction with red and green selenite plates, when a beautiful display of colours is obtained with certain starches, arrowroot and potato being those usually mentioned, while it is generally found that there is little coloration with cereal and leguminous starches. Tripe, in a paper on the discrimination of starches by polarized light in the *Analyst* (Vol. 20, p. 210), states: 'As a rule the starches obtained from seeds gave very little colour, whilst those from roots afforded much.'

It appears to the writer that comparatively few of the West Indian starches have hitherto been examined in this way, and his results will, no doubt, be found useful, especially in so far as they relate to the classification of starches according to Blyth's system, in which the starches are divided according to the presence or absence of iridescence when examined with polarized light. A large number of the starches described in this paper show brilliant coloration.

Several schemes for classification have been in use for some time. These are based upon the characteristic appearances exhibited by starch grains. Among the points

considered in the microscopic examination of starches, the following may be mentioned:—the surface, whether rounded or angular; the position of nucleus or hilum; surface markings; size, etc.

Three of these systems of classification will be referred to in this paper. First, that of Vogel, which is long and somewhat cumbrous; it is based primarily upon the shape of the grain and the position of the hilum. Twenty-two starches are classified by Vogel. The second system is Muter's. Muter has arranged between forty and fifty starches into five groups, according to the shape of the grains and the visibility of the hilum. This scheme does not give satisfaction. Undoubtedly the best system is Blyth's modification of Muter's. Blyth, in the earlier editions of his *Manual of Practical Chemistry* (1879), makes use of Muter's classification; in the later edition of this work, under the title of *Foods: their Composition and Analysis* (1882), however, he modifies Muter's scheme by the introduction of the distinctions based upon the action of the starches towards polarized light. The main division in this method is into two groups—those showing a play of colours with polarized light and those showing no iridescence. The starches in the latter group are, however, divided entirely according to Muter's scheme.

It would appear to be advisable to give here, in full, these three systems in order that the position, in them, of previously undescribed starches may be defined.

VOGEL'S TABLE OF THE STARCHES AND ARROWROOTS OF COMMERCE.

A. *Granules simple, bounded by rounded surfaces.*

I. Nucleus central, layers concentric.

(a) Mostly round, or from the side, lens-shaped.
E.g. *rye, wheat, barley.*

(b) Egg-shaped, oval, kidney-shaped: hilum often long and ragged.

E.g. *leguminous starches.*

II. Nucleus eccentric, layers plainly eccentric or meniscus-shaped.

(a) Granules not at all, or only slightly, flattened.

i. Nucleus mostly at the smaller end.
E.g. *potato.*

ii. Nucleus mostly at broader end or towards the middle. E.g. *arrowroot.*

(b) Granules more or less strongly flattened.

i. Many drawn out to short point at one end.
E.g. *Curcuma, Canna.*

ii. Many lengthened to bean-shaped, disc-shaped or flattened; nucleus nearer broader end.
E.g. *banana.*

iii. Many strongly kidney-shaped: nucleus near the edge. E.g. *Sisyrinchium.*

iv. Egg-shaped; reduced to wedge at one end, at the other enlarged; nucleus at smaller end.
E.g. *yam.*

B. *Granules simple or compound, single granules or parts of granules, either bounded entirely by plain surfaces, many-angled, or by partly round surfaces.*

I. Granules entirely angular.

i. Many with prominent nucleus. E.g. *rice.*
ii. Without a nucleus. E.g. *millet.*

II. Among the many-angled also rounded forms.

(a) No drum-shaped forms present, angular forms predominating; with or without nucleus.
E.g. *oats, buckwheat, maize.*

(b) More or less numerous kettledrum and sugar-loaf forms.

i. Very numerous eccentric layers. E.g. *sweet potato.*

ii. Without layers or rings.

(*a*) In the kettledrum forms nuclear depression mostly widened on the flattened side. E.g. *cassava.*

(*b*) Depression wanting or not enlarged. E.g. *yam bean, cho-cho.*

C. *Granules simple and compound; predominant forms, oval with eccentric nucleus and numerous layers; the compound granule made up of a large granule and one or more relatively small kettledrum-shaped ones.* E.g. *sago.*

MUTER'S TABLE FOR THE DETECTION OF STARCHES.

Group I. *All more or less oval in shape and having both hilum and rings visible.*
Examples—Canna, potato, arrowroot, ginger.

Group II. *With strongly developed hilum more or less stellate.*
Examples—Leguminous, nutmeg, maize.

Group III. *Hilum and rings practically invisible.*
Examples—Wheat, barley, rye, jalap.

Group IV. *More or less truncated at one end.*
Examples—Sago, tapioca, cassia, etc.

Group V. *All granules more or less polygonal.*
Examples—Tacca, oat, rice, pepper.

BLYTH'S CLASSIFICATION.

Division I. *Starches showing a play of colours with polarized light and a selenite plate.*

Class I. Hilum and concentric rings clearly visible, all oval or ovate. The group includes tous-les-mois, potato, arrowroot, ginger, etc.

Division II. *Starches showing no iridesence, or scarcely any, when examined by polarized light and selenite.*

Class I. The concentric rings all but invisible, and the hilum stellate. To this group belong the leguminous starches, maize and nutmeg.

Class II. Starches having both concentric rings and hilum invisible in most of the granules. This important class includes wheat, barley, rye. chestnut, acorn, and many starches in medicinal plants.

Class III. All granules truncated at one end. This group includes sago, tapioca, arum, several drugs and cinnamon and cassia.

Class IV. Granules all angular in form. Oats, rice pepper, etc.

(II) Microscopic Description of West Indian Starches.

In the following description of the starches the writer has endeavoured to indicate the positions each would occupy in the three schemes of classification. It has been necessary, however, in the case of Blyth's scheme, to make a new class in which are placed the starches of *Colocasia esculenta*, *Echites umbellata*, *Sechium edule*, the various Ipomoeas, etc. Blyth's Division I. (containing starches showing a play of colours with polarized light) has only one sub-division (Class I.), viz., 'hilum and concentric rings clearly visible, all oval or ovate': so that this classification does not allow for starches showing a play of colours which are not all oval or ovate. A second class (II.) is, therefore, added by the writer to Division I. to include such starches as those mentioned, which may be described thus:—hilum and concentric lines more or less invisible; variable in shape; among many-angled some rounded forms, sugar-loaf forms often present.

STARCH OF MANGO
(*Mangifera indica*).

As already stated, there are two forms of starch made from the mango, viz., that from the seed or kernel and that from the unripe mesocarp. These two forms make a particularly interesting study, since the grains of the one are entirely distinct from those of the other. Griffith* has drawn attention to the fact that different parts of the potato plant (tuber and fruit) contain starch grains possessing different characters; but here we have a still more remarkable fact, viz., the same fruit yielding two starches possessing entirely different characters, that from the kernel being composed of grains bounded by rounded surfaces, while the starch from the mesocarp has some angular grains with the rounded. The latter, too, are considerably smaller.

(a) *Starch from Seed.*

The surface of the grains is always rounded, usually regularly oval, though some are irregularly elongated oval, while a few are somewhat bean-shaped. The grains frequently show a streak down the centre. The hilum is faintly

* *The principal Starches used as Food (1892).*

visible, usually as a depression in the centre, sometimes distinctly stellate. The rings are practically invisible. (See fig. 5.)

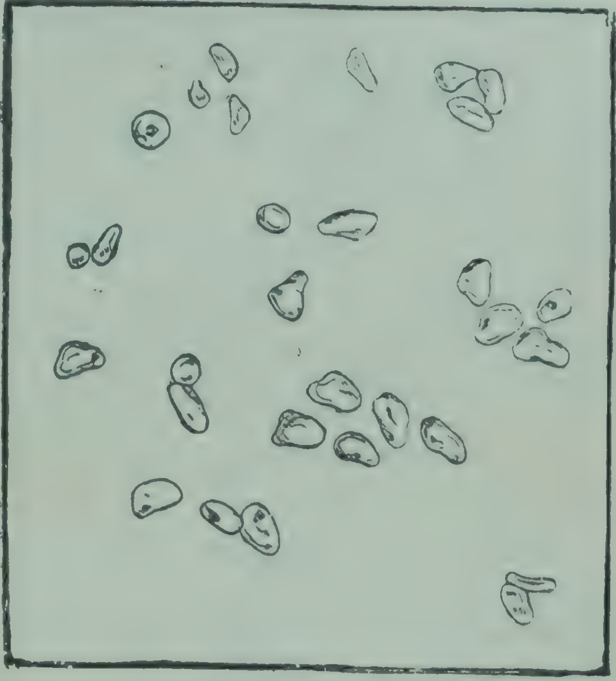

Fig. 5. Starch of the Mango Seed. [×300.]

With polarized light there is a play of colours; when so examined the cross is usually seen to meet in the centre, certainly always in the regularly oval-shaped forms. This confirms what has been said as to the central position of the hilum.

Size of Grains: In the matter of size, there is considerable variation. Although the average is 0·0157 mm., many of the grains are much larger, e.g., 0·0288 mm.

Position in Classification: In regard to the position of this starch in the three systems of classification, there can be no doubt that the starch from the mango seed should be placed in Blyth's Division I., Class I. In Muter's scheme also, it would probably fall into Group I: the only point in which it differs to any extent from the other starches of the group is in the visibility of the rings. In the case of Vogel's system, it would certainly go into Division A., Class I., but whether into the sub-division (a) or (b) it is difficult to say. The ragged hilum suggests a position with the leguminous starches.

(b) *Starch from Green Fruits.*

Here, as already mentioned, we have an entirely different form, as a glance at figs. 5 and 6 will show. The grains have more or less rounded surfaces, but while some are circular, many show the well-known sugar-loaf form. The markings are invisible, as also is the hilum.

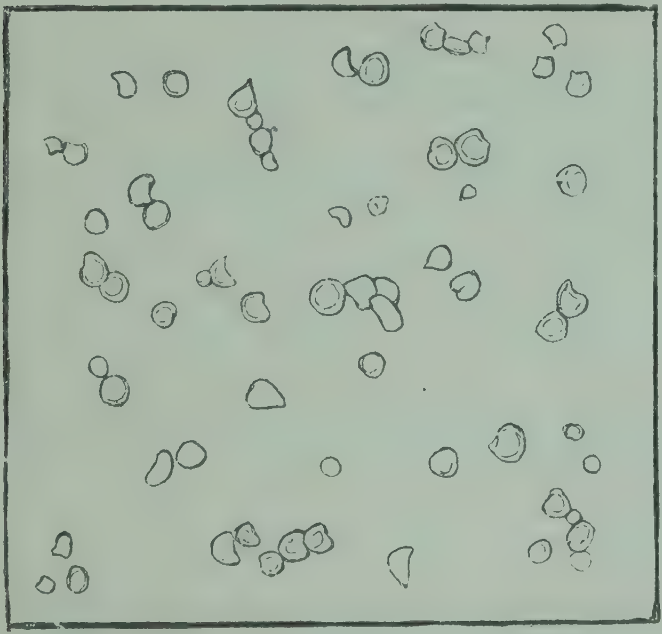

Fig. 6. Starch of the Green Mango. [×300.]

The starch is very similar to that of cassava. With polarized light there is a moderately brilliant display of colours, and the centre of the cross generally lies in the middle of the grain.

Size of Grains : In size, the grains vary from 0·0072 to 0·0168 mm., the average size being 0·0113 mm.

Position in Classification : This starch would probably be placed in Blyth's Division I., Class II., and Muter's Group IV.; while Vogel would most likely have placed it along with cassava in B., II., (b), ii., (*a*).

LEGUMINOUS STARCHES.

The different leguminous starches are so similar in appearance that one description will serve for the starches of Congo or pigeon pea (*Cajanus indicus*), the red pea (*Phaseolus vulgaris*) and 'Crab's eye' seeds (*Abrus precatorius*).

The granules are all bounded by rounded surfaces and are of decidedly uniform shape, viz., oval and kidney-shaped. The concentric markings are usually rather faint, and are apt to escape notice, unless specially looked for.

Fig. 7. Starch of the seed of *Phaseolus vulgaris*. [×300.]

The most characteristic feature of the grains of leguminous starches—one which makes their identification a comparatively simple matter—is the peculiar hilum (see fig. 7). This is central, but usually appears as a long, ragged slit in the direction of the longer axis. In some cases it has a somewhat star-shaped appearance.

The grains have very little effect on polarized light, the coloration not being particularly brilliant.

Size of Grains : Particulars as to the measurements of the grains of the different leguminous starches will be found on p. 39, and it is not necessary to refer to them individually here. It will be seen that the three starches referred to have grains measuring about 0·02 mm. to 0·04 mm., the grains of the pigeon pea being rather larger than those of the other two starches.

Position in Classification : The leguminous starches are placed by Blyth in Division II., Class I., by Muter in Group II., and by Vogel in A., I., (b).

Other Leguminous Starches.

The above is a general description of the characteristics of the starch grains of the principal leguminous seeds. There are, however, one or two exceptions that might be mentioned

here, viz., the starches of the ground nut (*Arachis hypogaea*) and of the seed of the yam bean (*Pachyrhizus tuberosus*). Of the former Griffith states in his book on starches: 'The starch in this nut exists only in small quantities, the amount being about 10 per cent. It is illustrated here to show that it differs considerably from other leguminous starches, being small and circular, with a distinct round hilum, and that it is, therefore, not safe to trust entirely to general characters when tracing a starch to its source.'

The starch grains in the seed of the yam bean appear to be very similar to those in the ground nut; but it has not been considered necessary to do more than make a brief reference to this starch.

STARCH OF YAM BEAN

(*Pachyrhizus tuberosus*).

Yam bean starch, when examined microscopically, is found to be entirely different from the characteristic form of the leguminous seed starches. It closely resembles, however, the starches of cho-cho, the ipomoeas, etc. That is to say, the grains are in some cases rounded, in others many-angled, while there are many kettledrum-shaped and sugar-loaf forms present. It is difficult to trace any appearance of hilum or nuclear depression or of concentric lines.

Examination with polarized light indicates the position of the hilum, which, as in the case of cho-cho starch, is central in the rounded forms and slightly eccentric in the truncated forms, being nearer the broader end. There is considerable iridescence with ploarized light.

Size of Grains: This varies somewhat, and yet the majority of the grains are about 0·0115 mm. in length. There are, however, a smaller number of large grains, which measure on an average 0·0226 mm. The range may be placed at from 0·01 to 0·0297 mm., the average of the whole being 0·017 mm.

Position in Classification: This is one of the starches which require a new class in Blyth's Division I. As already stated, it shows a brilliant play of colours with polarized light (placing it in Division I.), but the grains are not 'all oval or ovate,' nor are the lines distinctly visible. In Muter's scheme, yam bean starch would probably be placed in Group IV. Vogel has placed this starch along with that of cho-cho in B., II., (b), ii., (*b*).

Starch of Yam Bean Seed.

As already mentioned, the grains in the seed of this plant differ from those of most of the other leguminous seeds and also from those of the root of the yam bean itself. We have, then, still another instance of the same plant yielding grains of two entirely distinct forms—a point which has already been noticed in the case of the potato and of the mango.

STARCH OF CHO-CHO

(*Sechium edule*).

The only recorded observations on this starch appear to be those of Vogel, who places it in Group B., Division II., (b), ii., (*b*). It

would, therefore, come under the description: 'Among the many-angled also rounded forms; more or less numerous kettledrum and sugar-loaf-like forms; without layers or rings;' with the further description: 'without layers or rings, nucleus small, central or wanting; many irregular forms; 0·008 to 0·176 mm. in size.'

Examination by the writer brought out the following points:—(*a*) cho-cho starch shows a brilliant display of colours with polarized light, the position of the hilum being clearly indicated; (*b*) the hilum is eccentric and nearer the broad end; (*c*) layers or rings appear to be faintly visible; (*d*) in shape the grains are most irregular, some being circular, others many-angled, sugar-loaf-like and even bean-shaped.

Size of Grains: The writer's observations on this point are by no means in accord with Vogel's results, who states that the grains varied in size from 0·008 to 0·0176 mm. The writer found all sizes from 0·0144 to 0·0504 mm., the calculated average of a very large number being 0·0270 mm. It appears to be almost possible to divide the grains into two groups according to size—the larger grains being about 0·0456 mm. and the smaller 0·0190 mm.

Position in Classification: This is another of the starches mentioned on p. 20 as requiring a new sub-division (Class II.) in Blyth's scheme. In Muter's scheme this starch would probably be placed in Group IV. Vogel has placed it in his B., II., (b), ii., (*b*), but the fact that the hilum is fairly visible would necessitate a slight revision of the position that has been assigned to it.

STARCH OF NIGHTSHADE

(*Echites umbellata*).

It is doubtful if this starch has ever been examined before. In most of its characters it is very similar to that from the sweet potato (see fig 8). The grains are, also, very like those of bitter cassava, from which, however, the nightshade starch is distinguished by the following characters: (*a*) larger number of large, angular forms, (*b*) the appearance of being flattened on two or three sides, (*c*) the slight eccentricity of the hilum, and (*d*) the presence of faintly visible rings.

The grains are mostly circular in shape, though there are a number of sugar-loaf forms and some are many-angled. The hilum is slightly eccentric—in the sugar-loaf forms it is nearer the curved end. The lines are very faintly visible.

With polarized light there is a play of colours (not particularly brilliant), and the position of the hilum is confirmed.

Size of Grains: The grains vary in size from 0·0115 to 0·0224 mm., the average being 0·0151 mm. A comparison with the figures given for sweet potato starch will show that the average size is practically identical: with the latter, however, there is rather a wider range.

Position in Classification: The play of colours with polarized light would place this starch in Blyth's Division I.,

but on account of the rings being only faintly visible, and the presence of some angular forms, it is necessary to place it in Class II. of that division.

In Vogel's system, this starch would be placed with sweet potato starch in B., II., (b), i. It is difficult to assign it a position in Muter's scheme.

STARCH OF SWEET POTATO

(Ipomoea Batatas).

This starch will be found on Vogel's list, where it is placed in B., II., (b), i., that is, 'Among the many-angled also rounded forms: more or less numerous kettledrum and sugar-loaf-like forms.' A very brief description of this starch was given in the *Pharmaceutical Journal* (May 2, 1901).

The grains are very variable in shape: some are rounded or oval; others are much flattened, being almost three-sided; many also show the common kettledrum or sugar-loaf form, that is to say, they have the broader end truncate. As will be seen from fig. 8, some of the larger circular forms show near the circumference, a number of fine lines apparently radiating from the centre.

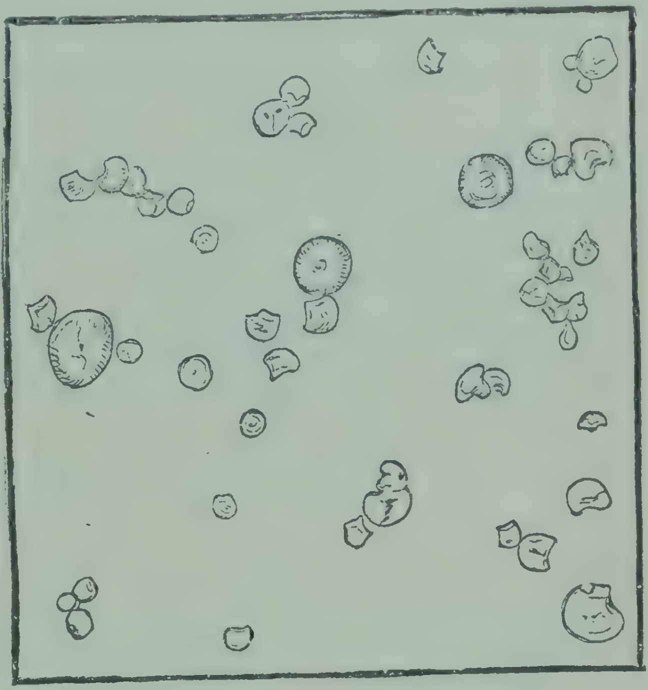

FIG. 8. Sweet Potato Starch. [× 300.]

The concentric rings are faintly visible surrounding the stellate hilum. The hilum is easily seen to be slightly eccentric; in the sugar-loaf forms it is nearer the curved end.

Examination with polarized light revealed a brilliant play of colours, the presence of a well-defined cross confirming what has been stated of the position of the hilum.

Size of Grains : The grains are as variable in size as they are in shape. While the average size is 0·013 mm., grains were found varying from 0·0071 to 0·0384 mm. The extent of this variation will be apparent, if the figures published by the following observers be examined :—

Vogel ...	...	0·022 to 0·0352 mm.
Karmarsch*	...	0·0450 mm.
Wiesner* ...	...	0·0369 mm.

*See Blyth : *Foods: their Composition and Analysis (1882).*

The writer of the note in the *Pharmaceutical Journal* referred to above, gives the following determinations :—

Large grains	...	0·025 to 0·050 mm.
Small ,,	...	0·015 to 0·022 mm.

With the exception of Vogel, all these observers appear to have found much larger grains than the writer, who found no grain of greater size than 0·0384 mm.

Position in Classification : Sweet potato starch is one of those which require a new sub-division in Blyth's system. As stated, the grains show a brilliant display of colours, but they are not rounded. It is, therefore, to be placed in Division I., Class II.

In Muter's scheme this starch would probably be placed in Group IV., while Vogel has, as already stated, placed it in B., II., (b), i.

STARCH OF IPOMOEA HORSFALLIAE.

There is really nothing to distinguish this starch from that of *I. Batatas*, except, perhaps, that there is a slightly more brilliant display of colours with polarized light. In this case, also, the grains are very variable in size and shape : the stellate hilum is eccentric.

Size of Grains : The average size is 0·014 mm., the grains varying from 0·0070 to 0·0264 mm. ; there appear to be fewer large grains than was the case with *I. Batatas.*

STARCH OF WILD POTATO

(*Ipomoea fastigiata*).

The description of sweet potato starch would also apply in this place, except, perhaps, that there is a larger proportion of specially large grains. Some of them measure as much as 0·048 mm. The average size is, however, much the same as that of the other species of this genus.

STARCH OF FOUR O'CLOCK

(*Myrabilis dichotoma*).

The grains of this starch are very small and it is in consequence difficult to make any observations as to distinctive characters.

The prevailing shape is polygonal with rounded angles. The hilum, which is central and more or less stellate, is distinctly visible, but there do not appear to be any other markings.

Size of Grains : As previously mentioned, these grains are very small, the average being only 0·0063 mm. Some grains are as small as 0·0048 mm., the largest being about twice that size, so that there is not much variation in size.

STARCH OF CORALITA

(Antigonon insigne).

The grains of this starch belong to a group which appears to contain a large proportion of the West Indian starches, viz., 'Among the many-angled some rounded forms, kettledrum and sugar-loaf forms being present.'

There are several different forms present in this starch—circular, polygonal with rounded angles, and the kettledrum-shaped forms. There are practically no signs of hilum or lines. The eccentric position of the hilum is, however, indicated when polarized light is employed: there is a fairly brilliant play of colours.

Size of Grains : The size of the grains tends to vary somewhat. The average size is 0·0158 mm.; there are grains as small as 0·0115 mm., while others are as large as 0·02 mm.

Position in Classification : It would appear advisable to place this starch in the same group as the starches of the *Ipomoeae*, cassava, etc.

STARCH OF CASSAVA.

It is impossible to trace any distinct difference between the starches of the two chief varieties—bitter cassava (*Manihot utilissima*) and sweet cassava (*M. Aipi*). The microscopic appearance of this starch has been described by many observers, notably by Blyth, Wiley, and Galt.

The outline of the grains varies, there being, apparently, two predominant forms, viz., one circular and the other sugar-loaf-shaped. There are also a few small grains showing a many-angled form.

The hilum occupies a central position in the circular forms, but in the kettledrum-shaped forms it is always nearer the curved end than the flat surface. Blyth makes special reference to a conical depression under the nucleus. No other markings are visible on these grains.

With polarized light there is a distinct play of colours, although this is not particularly brilliant. The cross appears when the field is dark and its centre indicates the position of the hilum.

Size of Grains : Considerable variation was found in the size of the grains, viz., from 0·0072 mm. to 0·0240 mm., the average being 0·0133 mm. This great variation is noticed by all observers and would appear to be characteristic of this starch. The following measurements, in millimetres, are given by different observers:—Wiley, 0·012; Galt; 0·015; Blyth, 0·014 to 0·019; Vogel, 0·008 to 0·022. It will thus be seen that the results of different observers are fairly uniform.

Position in Classification : Blyth places this starch in Division II., Class III., that is to say, among the starches showing little or no iridescence when examined by polarized light, all granules truncated at one end. This appears to be decidedly misleading, and the writer, considering that there is

sufficient play of colours to warrant its inclosure in Division I., would suggest that it be placed in Class II. of that division with the starches of the ipomoeas, cho-cho, etc., which it closely resembles.

In Vogel's scheme cassava starch is classed thus:— 'Among the many-angled, some rounded, more or less numerous drum-shaped to sugar-loaf forms, without concentric circles; in the kettledrum-shaped granules the nuclear depression widened on the flattened side.'

Muter places 'tapioca' starch in Group IV. (more or less truncated at one end), remarking: 'shape roundish, a little over 50 per cent. truncated by one facet, and a pearly hilum.'

STARCH OF BREAD-FRUIT

(*Artocarpus incisa*).

There appears to be no record of any previous observations on this starch. The grains are for the most part polygonal with rounded angles. As Vogel would say, 'among the many-angled also rounded forms', but there are no sugar-loaf forms present and the angular forms predominate. There is no sign of any hilum or other markings. (See fig. 9.)

In outline the grains are very similar to those of maize or Indian corn. The absence of a hilum, however, is the distinguishing point, when this starch is compared with corn starch, of which the prominent, stellate hilum is so characteristic.

FIG. 9. Starch of Bread-fruit. [× 400.]

With polarized light there is practically no display of colours.

Size of Grains: A large number of measurements give an average of 0·0077 mm., with a range of from 0·0048 to 0·0120 mm.

Position in Classification: Like corn starch, this starch goes into Division II. of Blyth, but the absence of a stellate hilum will cause it to be placed in Class II. along with most of the cereal starches. Similarly, it must be placed in Muter's Group III. In Vogel's system, it will go among the 'many-angled and rounded forms' of Group B., Division II. The absence of drum-shaped forms places it in sub-division (a), and it would probably be placed finally with oat starch, i.e., B., II., (a).

STARCH OF JACK-FRUIT

(*Artocarpus integrifolia*).

There is very little to distinguish this starch from that of bread-fruit. If anything, it is, perhaps, a very slight play of colours, but not sufficient to place it in Blyth's Division I. In size, too, the two starches are practically identical.

STARCH OF TOUS-LES-MOIS

(*Canna edulis*).

Excellent photographs of this starch and that of *Canna indica* will be found in Griffith's *The principal Starches used as Food.* Its appearace has also been described in detail by Blyth, Galt, and others.

The grains of this starch are easily distinguished from any other grains on account of their great size and the distinctness of their markings. In appearance they resemble those of the potato tuber, but, being of greater size, they can usually be detected without much difficulty. The smaller grains are more or less circular in shape, but the larger are more of an oval shape, frequently somewhat flattened, especially at the ends.

The hilum is eccentric, being nearer to the smaller end. One of the chief characteristics of the grains of this starch is the clearness with which the concentric rings are to be seen. These markings are very regular, although the rings are not complete.

With polarized light there is a brilliant illumination: with a dark ground the cross is very distinct, its centre indicating very clearly the position of the hilum.

Size of Grains : These are the largest known starch grains: some of them are no less than $\frac{1}{10}$ mm. in the long diameter. The grains vary very much in size, however, and there are usually a large number of small, very irregularly shaped grains. The long diameter varies from 0·03 to 0·1 mm., while the average size of the grains is 0·055 by 0·038 mm. The following measurements are given by other observers:—Blyth, 0·0469 to 0·0939 mm.; Galt, 0·07 mm. by 0·05 mm.; and Muter, 0·0457 to 0·0940 mm.

Position in Classification : The positions assigned to canna starch in the various systems of classification are indicated on pp. 18-20 as follows: —Vogel, A., II., (b), i.; Muter, Group I.; Blyth, Division I., Class I.

STARCH OF INDIAN SHOT

(*Canna indica*).

The starch of the Indian shot is very similar to that of Tous-les-mois. The concentric lines are stated by Griffith to be more distinct. The large grains are, perhaps, a trifle smaller, although the average size is about the same, viz., 0·055

by 0·038 mm. No grains were noticed having a greater diameter than 0·08 mm.

STARCH OF ARROWROOT

(*Maranta arundinacea*).

The starch of arrowroot (*Maranta arundinacea*), is another that has frequently been described. The grains are all bounded by a rounded surface, and while most of them are oval, some are circular and others are so flattened as to be almost triangular with very rounded angles. This form is described as 'mussel-shaped'. Though somewhat variable, the shape is quite characteristic. The hilum is central in some forms (chiefly the circular), in others it is slightly eccentric, being nearer the broader end. In some forms, again, it is decidedly linear, having somewhat the appearance of crab's legs. The rings are faintly visible being more readily seen in the larger forms.

With polarized light the grains exhibit a brilliant display of colours, and the cross marks clearly the position of the hilum.

Size of Grains : There is no very great variation in the size of arrowroot grains, which is from 0·0228 to 0·0456 mm., the average size being 0·031 mm. They are, it will be seen, very much smaller than the canna starches, from which it is sometimes necessary to distinguish them. The following are some of the published results of measurements :—Blyth, 0·01 to 0·07 mm. ; Galt, 0·035 mm.; Vogel, 0·02 to 0·06 mm., and Wiesner 0·01 to 0·07 mm.

Position in Classification : In all schemes of classification this starch comes close to canna starch. Vogel, however, separates them according to the degree of flattening. Both arrowroot and canna starch are placed by him in A., II., but arrowroot is described as having granules 'not at all or only slightly flattened', while canna starch has grains more or less strongly flattened.

STARCH OF GINGER

(*Zingiber officinale*).

All observers of this starch agree in considering the shape variable, but at the same time characteristic. The predominant form is shortly conical with rounded angles, many of the smaller grains being cylindrical or circular in outline. The hilum and rings were seen only with considerable difficulty, which is a point noted by all observers.

With polarized light there is a play of colours, which, however, can scarcely be called brilliant.

Size of Grains : The average of a large number of measurements was 0·0236 mm., the variation being between 0·0168 and 0·0408 mm. Blyth gives 0·0376 mm. : Muter, 0·0376 mm.

Position in Classification : This starch is placed by Blyth and Muter along with the starches of canna, arrowroot and potato. In Vogel's scheme, it would probably go into A., II, (b).

STARCH OF BANANA

(*Musa sapientum*).

The granules of banana starch are all bounded by rounded surfaces, but are also all markedly flattened. While most of them may be described as oyster-shaped, or perhaps, more or less pear-shaped, many are club-shaped and others bean-shaped. The nucleus or hilum is distinctly eccentric, being placed much nearer one end—sometimes the narrow, sometimes the broader end. The concentric lines are plainly visible, though not complete. (See fig. 10.)

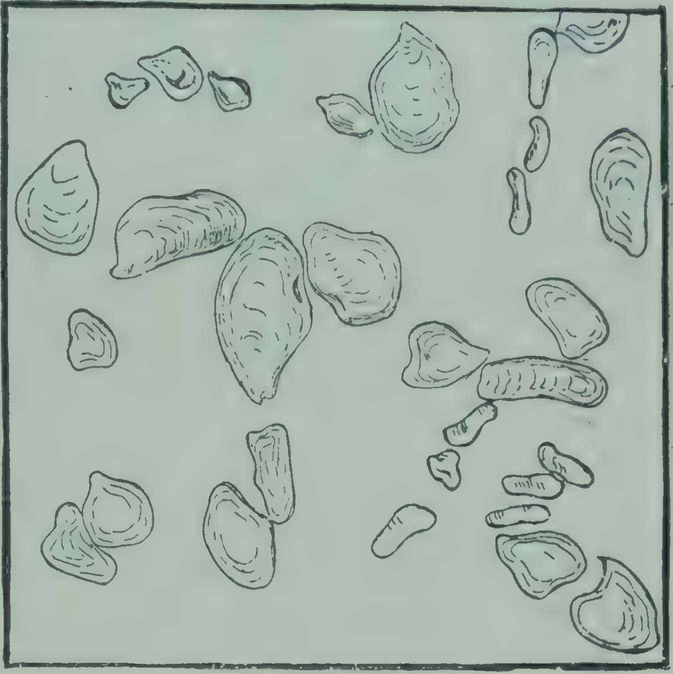

FIG. 10. Banana Starch. [×220.]

There is a play of colours with polarized light, though this is not very brilliant.

Size of Grains: The writer found these grains to vary between 0·026 and 0·0744 mm., the average being 0·0466 mm.

Apparently, the only published measurements are those of Vogel (0·044 to 0·075 mm.) and of a writer in the *Pharmaceutical Journal* (June 6, 1901), who states that the largest grains measure 0·045 to 0·065 mm., the smallest about 0·007 mm., and the intermediate grains from 0·022 to 0·034 mm.

Position in Classification: In spite of the fact that the play of colours with polarized light was not particularly brilliant, there is no doubt that this starch would find a place in Blyth's Division I. Similarly, banana starch must be placed in Muter's Group I. Vogel has already classified this starch, which he places in A., II., (b), ii. His description would therefore be:—'Granules simple, bounded by rounded surfaces; nucleus eccentric, granules more or less strongly flattened: many lengthened to bean-shaped, disc-shaped or flattened; nucleus nearer broader end.'

STARCH OF PLANTAIN

(*Musa sapientum*, var. *paradisiaca*).

The granules of plantain starch are bounded by rounded surfaces; they vary greatly in shape, some being more or less oval, whilst others are much flattened and drawn out into disc-, bean-, or club-shaped forms. This starch is to be distinguished from banana starch by the presence of a larger

number of long, straight, narrow forms, and by the greater uniformity in size and shape. (Cf. figs. 10 and 11.) The concentive lines are not as distinct as those on the banana grains, and the eccentric hilum, which appears to be more often nearer the broader end, is less distinct.

FIG. 11. Plantain Starch. [× 220.]

With polarized light there is slight iridescence, possibly rather more than with banana starch.

Size of Grains: The grains are rather smaller than those of banana starch. They average 0·0347 mm., the range being from 0·0192 to 0·0528 mm.

Position in Classification: As there is nothing but the presence of the elongated forms to distinguish this starch from banana starch, plantain starch will have to be placed in similar positions in the schemes of classification.

YAM STARCH.

The only description of this starch which the writer has come across is a very brief one, which appeared in the *Pharmaceutical Journal* (April 6, 1901).

Vogel has classified it: he found that it possessed the following characters:—'Single granules, bounded by rounded surface; nucleus eccentric; granules more or less strongly flattened, egg-shaped, at one end reduced to a wedge, at the other enlarged, nucleus at smaller end.'

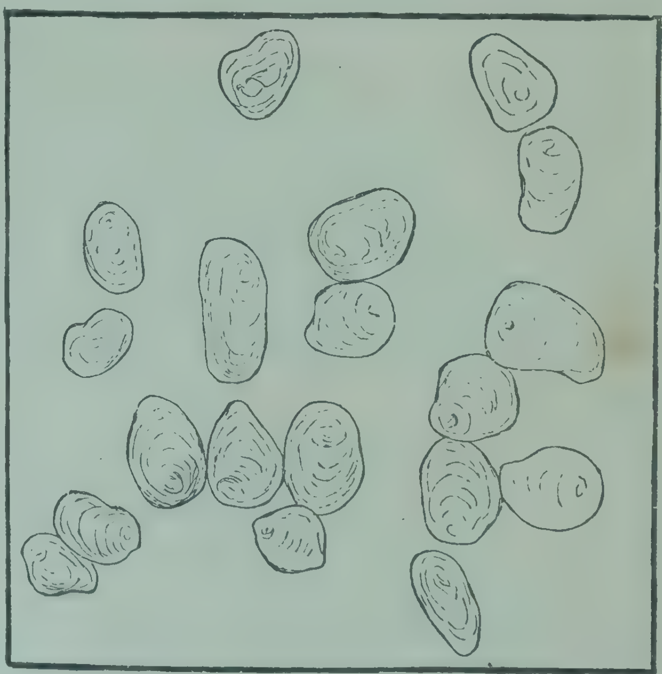

FIG. 12. Yam Starch. [× 300.]

The following notes will complete the description of yam starch:—All the granules are rounded, most of them being circular or ovate; a few are, however, much elongated to give, as noted by Vogel, a wedge-shaped appearance, though the surface is

still rounded. The eccentric nucleus is just visible, as also are the concentric rings. Fig. 12, which is a reproduction of an original photograph of yam starch, shows clearly the position of the hilum. This, it will be seen, is most distinctly nearer the broad end of the grain: this was the position occupied by the hilum in all the specimens of yam starch examined by the writer; in no instance was it found nearer the smaller end of the grain as stated in the description by Vogel quoted on the last page.

Examined with polarized light, yam starch grains show a brilliant play of colours, and the intersection of the cross confirms what has been said of the position of the hilum.

Size of Grains: The results of measurements of yam starch grains will be found in the table on p. 40, where figures for six varieties of yam are given. It will be seen that the average size of the grains is 0·0406 mm. The variation is not very great: in none of the yams was the writer able to find grains having a greater diameter than 0·0576 mm., although Vogel gives the size of the yam grains as varying from 0·05 to 0·07 mm. The measurements given in the *Pharmaceutical Journal* are: largest grains, 0·045 to 0·09 mm. in length and 0·025 to 0·06 mm. in breadth, while the smaller vary from 0·015 to 0·030 mm. in length and about half that in breadth.

Position in Classification: It is impossible to place this starch otherwise than in Blyth's Division I., Class I. Muter would no doubt place it in his Group I.; while Vogel has, as already stated, placed it in A., II., (b), iv.

As will be seen from the list given on p. 40, a large number of different varieties of yam were examined, but the appearance of the starches from them was so characteristic and uniform, that there seemed to be no reason for describing them separately. Except for slight differences in the matter of size, the starches of the different yams appear to be identical.

With the description given above and the aid of fig. 12, observers should have no difficulty in identifying yam starch.

STARCH OF TANNIA OR COCO

(*Colocasia esculenta*).

There appears to be no published description of this starch. There is considerable variation in the shape of the grains, but although there are some circular forms, the prevailing form is polygonal with rounded angles. The hilum is stellate or linear and occupies a central position. Altogether, there is much resemblance between this starch and maize starch in size and general appearance. There is a fair display of colours with polarized light, the lines of the black cross meeting in the centre.

Size of Grains: The grains vary in size from 0·0060 to 0·0192 mm., the average size being 0·0114 mm.

FIG. 13. Starch of Tannia. [× 300.]

Position in Classification: It is somewhat difficult to classify this starch: its great resemblance to maize starch would suggest a place near that starch, and yet it would appear to be separated from it on account of its behaviour towards polarized light, there being much greater iridescence in the case of tannia starch. Taking Blyth's system, it would seem to be necessary to place tannia starch in the second class of the first division. There is no doubt that Vogel would have placed this starch with maize; and similarly, in Muter's scheme it would have a place in Group II.

STARCH OF THE WILD TANNIA.

The grains of this starch are extremely small—so small that it is difficult, with the lenses used for the rest of the starches, to observe any distinguishing characters. So far as can be seen, however, the grains are fairly uniform in shape, which, as in the case of the tannia starch, may be described as polygonal with somewhat rounded angles. There is a faint trace in some grains of a hilum, probably linear or stellate, situated in the centre of the grain. It would appear, therefore, that the difference between this starch and that of the preceding (cf. figs. 13 and 14) is mainly one of size.

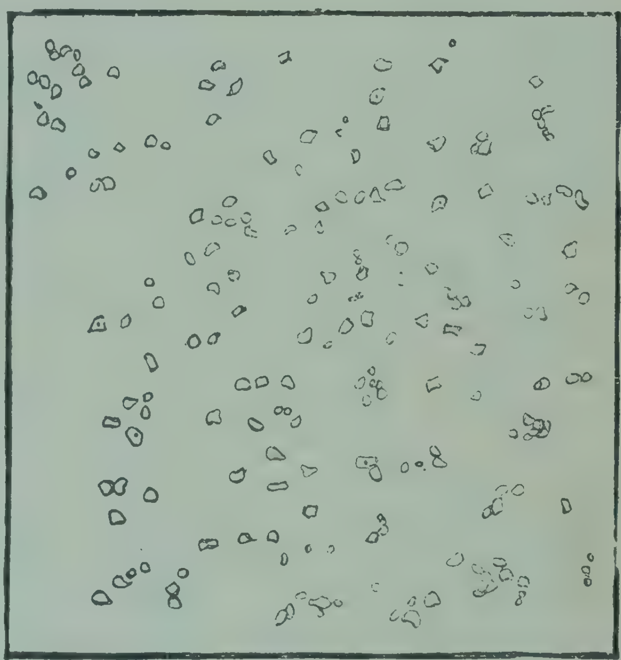

FIG. 14. Starch of Wild Tannia. [× 300.]

STARCH OF MAIZE OR CORN

(*Zea Mays*).

A description of this starch is to be found in practically every work on the microscopy of the starches. In shape

most of the grains are polygonal with rounded angles: there are also many rounded or circular forms present. The maize starch granule is generally regarded as typical of the angular starches. As a general rule, no trace of concentric lines is seen, but a few of the grains, especially the rounded forms, show them faintly. The hilum is well developed, occupying a central position and is usually more or less star-shaped.

Examined with polarized light these grains are found to present the customary appearance of cereal starches. When the ground is light, the grains stand out as bright objects, but show no brilliant coloration. When the ground is dark, the black cross is seen very clearly, dividing the grains into four, almost equal, parts, the two bands of the cross meeting exactly at the centre of the grain.

Size of Grains: The variation in size is not great—from 0·01 to 0·02 mm.—the average being 0·0138 mm. The following measurements are on record:—Galt, 0·008 to 0·02 mm. (average, 0·014); Karmarsch, 0·030 mm.; Wiesner, 0·020 mm.; and Wiley, 0·02 to 0·03 mm.

Position in Classification: The originators of the three schemes of classification have themselves placed maize starch in its position; thus, Blyth in Division II, Class I. (no iridescence, rings all but invisible, hilum stellate); Muter in Group II.; Vogel in B., II., (a).

STARCH OF GUINEA CORN

(*Sorghum vulgare*).

There is very little to distinguish Guinea corn starch from that of maize.

The shape is fairly uniform, viz., mostly polygonal with rounded angles, with some grains more or less circular. The hilum is distinctly prominent: usually it is more or less stellate (in most cases there radiate from the centre three short lines equidistant to one another), though in some forms the hilum appears merely as a circular depression. No rings or other markings are observable.

FIG. 15. Guinea Corn Starch. [× 220.]

With polarized light there is little coloration, but the position of the hilum is distinctly indicated. (See fig. 15.)

Size of Grains: The average size of the grains is 0·0178 mm.: the measurement in

some cases was as low as 0·0132 mm., while in others it reached 0·0247 mm.

Position in Classification: To be placed with maize all through.

(III) Classification of the Foregoing Starches.

As a result of the observations made on the foregoing starches, the writer would suggest that they be classified as follows according to Blyth's system (see pp. 19-20) modified by the addition of Class II. in Division I.:—

Division I. Starches showing a play of colours with polarized light and a selenite plate.

Class I.—The hilum and concentive rings clearly visible, oval or ovate:—Mango (seed), yam, banana, plantain, cannas, arrowroot and ginger.

Class II.—Hilum and concentric rings more or less invisible; variable in shape; among many-angled some rounded forms; sugar-loaf forms often present:—Mango (green), yam bean, cho-cho, 'nightshade,' ipomoeas, coralita, cassava and tannia.

Division II. Starches showing no iridescence, or scarcely any, when examined by polarized light and selenite.

Class I.—The concentric rings all but invisible, and the hilum stellate:—Leguminous starches, maize, Guinea corn.

Class II.—Starches which have both the concentric rings and hilum invisible in the majority of granules:—Bread-fruit and jack-fruit.

Class III.—All the granules are truncated at one end:—None.

Class IV.—In this class all the granules are angular in form:—None.

CONCLUSION.

Several interesting points are presented in this study of the West Indian starches and these might usefully be summarized here.

The large majority of these starches are obtained from roots and tubers; several are obtained from fruits, either ripe or in the green stage before the starch has been converted into sugar; while the only seeds in the list are the various leguminous seeds and maize and Guinea corn. This preponderance of root starches constitutes one of the chief differences between West Indian and English starches, the majority of the latter being from cereal seeds. The whole of the starches obtained from roots and tubers are described as showing a play of colours with polarized light and are in consequence placed in Division I. in Blyth's system of classification. Here they fall quite easily into two divisions. In the first are those bounded by rounded surfaces (i. e., either oval or ovate); hilum and concentric rings clearly visible. The examples are the yams, the cannas, arrowroot and ginger. It will at once be noticed that these plants belong to natural orders which are not far

removed from one another; and emphasis is added to this, when it is observed that among the remaining starches in this group are to be found those of the tribe *Museae* (banana and plantain).

With regard to the remaining 'root' starches, they all agree in several characters. They all show some coloration with polarized light, and among the many-angled there are some rounded forms, sugar-loaf forms being often present. There is so much similarity among these starches that it will not be found an easy matter to distinguish them until details as to appearance of hilum, measurements, etc., are taken into account. The only starch in this group that is not a 'root' starch is that obtained from the green mango; just as the only 'seed' starch in Class I. was mango starch. So that, altogether, the mango starches are full of interest: first, we have the two entirely different forms in the one fruit, and secondly, these two forms occupy unique positions in our system of classification. The further study of fruit starches would, perhaps, be a profitable one. So far as can be seen at present, there is very little uniformity: thus, the starch of the green mango is not placed with the starch of the green plantain and the green banana, but, strange to say, the seed starch is. As a general rule, it is stated that seed starches (at any rate, those of the cereals) show no iridescence with polarized light; mango seed starch, however, gives quite a brilliant play of colours.

Coming now to the starches showing little or no iridescence when examined with polarized light, mention should be made of the leguminous starches. Here we have considerable uniformity: the starches of the pigeon pea (*Cajanus indicus*), the red pea (*Phaseolus vulgaris*) and crab's eye seeds (*Abrus precatorius*) all exhibiting the well-known oval or kidney forms with ragged hilum, of uniform shape and size. An exception has, however, to be noted in the case of ground nut starch (*Arachis hypogaea*), as also in the case of the starch from the root of the yam bean (*Pachyrhizus tuberosus*). In the case of the latter we have what may be called the usual dicotyledonous 'root' form of starch instead of the typical leguminous seed form. Evidently the striking uniformity in the case of leguminous starches is confined to the seeds.

The only cereal starches on this list will be found classed with the leguminous starches; the only points of resemblance, however, are the invisibility of concentric rings, the absence of iridescence with polarized light, and the presence of a more or less stellate hilum. The starches of bread-fruit and jack-fruit are placed by themselves in the class which contains wheat, barley, rye, etc. None of the West Indian starches that have been examined by the writer, have been placed in Classes III. and IV. of Division II. in Blyth's system.

It would appear that the examination of such a large number of 'root' starches, as recorded in this paper, serves to bring out the unsatisfactory nature of any such artificial schemes for classification as those that are in use at the present time, and also the need for their revision as suggested in this

paper. Blyth's system is undoubtedly the least unsatisfactory, but it appears to have been adapted from Muter's without sufficient alteration and possibly without a sufficiently extensive examination of starches, especially of those from roots.

Another interesting point is brought out by this investigation, which appears to be worthy of mention here. While, in most cases, there is a more or less distinct resemblance between the starch grains of plants in any particular family, several instances have been recorded where there is a decided variation. As has been pointed out, the grains of the tannia root are certainly very much larger than those of the wild tannia, and there may be other points of difference not readily noticed in such small grains, although the wild tannia is considered to be merely a variety of *Colocasia esculenta*. The yam bean root contains starch grains which in no way resemble those of the principal leguminous seeds, but which do resemble those of other dicotyledonous roots; the yam bean seed and the ground nut, again, have starch grains of still another form. Further, it has been shown that banana starch can be distinguished from the starch of the plantain, which does not show any specific differences from the banana. In spite of this, we have all the different species of *Dioscorea* containing starch grains of one form with practically nothing to distinguish them: this is also the case with the ipomoeas, the two species of *Artocarpus* and the cannas.

The detailed descriptions of authentic specimens of a large number of starches are likely to be useful to chemists in the West Indies, as also in other countries, particularly now that so many attempts are being made to extend the uses of many starchy products by the manufacture of meals, etc.

Apart altogether from the question of the microscopic appearances of the West Indian starches, these notes are likely to be of interest to planters and others as suggesting further uses for some of the common plants in the West Indies. It has been pointed out that there are some that might be utilized as producers of starch for laundry purposes, while in other cases easily digested food, suitable for infants and invalids, might be obtained, as for example, from the cho-cho root and the yam bean.

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TABLE OF MEASUREMENTS.

Name.	Range.	Average.
Sour sop (*Anona muricata*) ...	0·0024 - 0·0096	0·0054
Mango (*Mangifera indica*) green	0·0072 - 0·0168	0·0113
do. kernel	0·0096 - 0·0288	0·0157
Crab's eye (*Abrus precatorius*) ...	0·0250 - 0·0400	0·0304
Pigeon pea (*Cajanus indicus*) ...	0·0216 - 0·0480	0·0245
Red pea (*Phaseolus vulgaris*) ...	0·0216 - 0·0360	0·0290
Yam bean (*Pachyrhizus tuberosus*) ...	0·0100 - 0·0297	0·0170
Cho-cho (*Sechium edule*) ...	0·0144 - 0·0504	0·0270
Nightshade (*Echites umbellata*)...	0·0115 - 0·0224	0·0151
Sweet potato (*Ipomoea Batatas*)	0·0071 - 0·0384	0·0130
Ipomoea Horsfalliae ...	0·0070 - 0·0264	0·0143
Ipomoea fastigiata ...	0·0084 - 0·0480	0·0144
Four o'clock (*Myrabilis dichotoma*) ...	0·0048 - 0·0096	0·0063
Pink coralita (*Antigonon insigne*) ..	0·0115 - 0·0198	0·0158
Cassava (*Manihot*) ...	0·0072 - 0·0240	0·0133
Bread-fruit (*Artocarpus incisa*)	0·0048 - 0·0120	0·0077
Jack-fruit (*Artocarpus integrifolia*) ...	0·0048 - 0·0120	0·0086
Tous-les-mois (*Canna edulis*) ...	0·0300 - 0·1000	0·0550 x 0·0380
Indian shot (*Canna indica*) ...	0·0290 - 0·0800	0·0550 x 0·0380
Arrowroot (*Maranta arundinacea*) ...	0·0228 - 0·0456	0·0310

TABLE OF MEASUREMENTS.—(*Concluded.*)

Name.	Range.	Average.
Ginger (*Zingiber officinale*) ...	0·0168 - 0·0408	0·0236
Banana (*Musa sapientum*) ...	0·0261 - 0·0744	0·0466
Plantain (*Musa sapientum*, var. *paradisiaca*) ..	0·0192 - 0·0528	0·0347
Yampie (*Dioscorea trifida*) ...	0·0288 - 0·0576	0·0457
Yellow yam	0·0336 - 0·0504	0·0416
Lucea yam ...	0·0336 - 0·0480	0·0398
Negro yam	0·0384 - 0·0576	0·0461
White flour yam	0·0240 - 0·0456	0·0307
White yam	0·0288 - 0·0480	0·0400
Tannia (*Colocasia esculenta*) ...	0·0060 - 0·0192	0·0114
do. (wild) ...	0·0020 - 0·0048	0·0030
Maize (*Zea Mays*) ...	0·0100 - 0·0200	0·0138
Guinea corn (*Sorghum vulgare*) ...	0·0132 - 0·0247	0·0178

Note Added :—

Since the foregoing was written, an interesting note has appeared in the *Bulletin of the Imperial Institute* (Vol. II, no. 1) on starch prepared from the bread-fruit tree in the Seychelles. Two samples—one sifted and one unsifted—were forwarded by the Governor of Seychelles to the Imperial Institute with a request that a report upon their composition and commercial value should be furnished.

Analyses and microscopic examination showed that the powders were practically pure starch. The specimen of sifted powder was submitted to brokers for valuation. It was reported that there would probably be a good demand for the material at £7 per ton, c.i.f. London. 'The present value of American powdered starch is about £8 10*s*. per ton in London, so that the value of the Seychelles product might improve as it became known.'

EXPERIMENTS WITH SWEET POTATOS AT BARBADOS.

BY R. R. HALL, B.A., AND J. R. BOVELL, F.L.S., F.C.S.

In 1901, an effort was made to ascertain the best sweet potatos cultivated in Barbados by growing a certain area of each variety under similar conditions, and twenty-eight varieties were planted at Waterford estate in a field under the direction of the Imperial Department of Agriculture.

These plots grew well at first, and at one time there was every prospect of satisfactory results being obtained. Unfortunately, however, as soon as they were about two months old, they were attacked by the insect pests which were then prevalent in Barbados on the sweet potato plants. So great was the injury done that it was impossible to get any reliable data from the experiments, consequently they were abandoned.

In June 1902, another effort was made to carry out these experiments and the following twenty-eight varieties were planted in Foaster field at Waterford, viz:—Barker, Bequia, Blue Bird, Boot Heel, Brass Cannon, Caroline Lee, Cover-the-World, Fill-the-Pot, Fire Brass, Honeychurch, Hurley, Joe Mende, Johns, Love Drops, Minuet, Moffard, Red Bourbon, Red Sealy, Trinidadian, No. 1 from Trinidad, No. 2 from Trinidad, No. 4 from Trinidad, Vincelonian, White Bourbon, White Gilkes (which takes three months to mature), White Gilkes (which takes six months to mature), White Mary, White Sealy.

In the following September, small green caterpillars and flea beetles commenced eating the leaves, etc., but Mr. Maxwell-Lefroy, then Entomologist of the Department, immediately sprayed them with a mixture of Paris green, lime, molasses, and water. This had the desired effect, and soon the vines were free from insects and remained so until the potatos were dug. In spite, however, of the prompt measures taken to eradicate these pests, they appear to have affected the yield, as the weights per acre of some of the varieties are below what may be regarded as the average yield of sweet potatos in Barbados.

Table I. gives the chief results, in pounds per acre, of the different varieties, arranged in alphabetical order. This table shows their relative values as food, and the amount of nitrogenous and mineral substances removed from the land.

'Food units : pounds per acre' expresses approximately the calculated relative food value of the variety.

Potatos, containing very little more than starch, require to be supplemented by peas or beans to supply the needs of the animal economy.

The following list contains the yields in food units of those varieties which gave the best return ;—

	Total weight of potatos. Pounds per acre.		Food units. Pounds per acre.
White Gilkes (six months)	11,116	...	4,002
Hurley	10,275	...	3,597
Minuet	9,903	...	3,366
Vincelonian	7,823	...	3,129

Table II. gives the field results in tons per acre.

Table III. gives the detailed analyses of the potatos.

Table IV. gives the detailed analyses of the vines.

The following is a brief description of the potatos after they were cooked :—

Barker : Skin white, centre pale dull yellow, waxy. Flavour fair.

Bequia : Skin white, pale dull yellow throughout, waxy. Flavour fairly good.

Blue Bird : Skin white, centre fibrous, pale dull yellow. Flavour poor. An undesirable variety.

Boot Heel . Skin pale red, centre white and dry, surrounded by a layer of white waxy tissue. Flavour medium.

Brass Cannon : Skin red, pale dull yellow and floury throughout. Flavour good.

Caroline Lee : Skin yellowish white, centre dry and yellow ; with the exterior portion of a duller yellow. Flavour very good, but does not keep well.

Cover-the-World : Skin white, white and floury throughout. Flavour poor.

Fill-the-Pot : Skin white, centre white and floury passing into a dull white waxy condition next the skin. Flavour good.

Fire Brass : Skin pale red, centre pale yellow and waxy throughout. Flavour fairly good.

Honeychurch : Skin white, centre fibrous, pale dull yellow throughout. Flavour medium.

Hurley : Skin pale red, dull yellow, fairly dry and floury throughout. Flavour medium.

Joe Mende : Skin white, centre white and floury, surrounded by a layer of pale dull yellow. Good flavour, somewhat like chestnuts.

Johns : Skin pale pink, centre white, floury, surrounded by a layer of yellowish white waxy tissue. Flavour fair.

Love Drops : Skin white, centre white and dry, surrounded with a layer of waxy dull yellow tissue. Flavour fair.

Minuet : Skin yellowish white, centre dull yellow and waxy throughout. Flavour good.

Moffard : Skin red, centre white and floury, surrounded by a layer of waxy, dull yellow tissue. Flavour very good.

Red Bourbon : Skin red, centre yellow, surrounded by a layer of waxy yellowish tissue. Flavour fair.

Red Sealy: Skin red, centre white and dry passing into a yellowish white waxy condition in the outer portion. Flavour very good and a variety that keeps well.

Trinidadian: Skin red, centre white gradually passing into a waxy condition next the skin. Flavour fairly good.

No. 1 from Trinidad: Skin white, centre bright yellow, waxy. Flavour fair.

No. 2 from Trinidad: Skin pale red, centre pale dull yellow throughout, soft and waxy. Flavour medium.

No. 4 from Trinidad: Skin red, centre yellow and dry with a surrounding layer of waxy dull yellow tissue. Flavour medium.

Vincelonian: Skin red, centre pale yellow, mottled with a darker shade of yellow; fairly floury. Flavour good.

White Bourbon: Skin white, soft and yellow throughout. Flavour not good.

White Gilkes, which takes three months to mature: Skin yellowish white, centre white and floury, surrounded by a layer of waxy yellowish white tissue. Flavour very good.

White Gilkes, which takes six months to mature: Skin white, centre white and floury, surrounded by a layer of yellowish white tissue. Flavour very good, and a variety that keeps very well.

White Mary: Skin white, centre white, fibrous, surrounded by a layer of pale dull yellow. Flavour fair.

White Sealy: Skin white, white and floury throughout. Flavour good.

TABLE I.—SUMMARY OF CHIEF RESULTS.

VARIETIES.	POTATOS.								VINES.				
	Total weight of potatos. Pounds per acre.	Weight of large.	Weight of small.	Starch. Pounds per acre.	Food units. Pounds per acre.	Nitrogen.	Phosphoric Anhydride.	Potash.	Weight of Vines. Pounds per acre.	Food units. Pounds per acre.	Nitrogen.	Phosphoric Anhydride.	Potash.
Barker	6336·0	3802·8	2536·8	2101·65	2,472	12·66	10·14	22·80	13248·0	1,854	46·38	35·76	58·29
Bequia	7718·4	4435·2	3283·2	2300·85	2,700	20·07	13·89	28·56	4953·6	744	22·29	12·39	16·35
Blue Bird... ...	2937·6	1094·4	1843·2	873·93	1,002	5·58	5·58	10·59	11059·2	1,437	43·14	24·33	40·92
Boot Heel... ...	3388·2	2710·5	677·7	1129·29	1,287	9·84	5·07	13·20	5929·5	1,008	25·50	15·42	31·44
Brass Cannon ...	7814·1	7052·9	762·3	2316·87	2,736	21·87	16·41	17·97	7560·0	1,134	38·55	16·62	21·18
Caroline Lee ...	5430·9	3764·7	1666·2	1498·38	1,791	15·75	11·40	23·34	6171·3	987	29·01	19·74	38·88
Cover-the-World	7219·9	5976·9	1243·0	2562·30	3,033	24·54	7·23	12·99	7042·2	915	24·66	16·20	40·83
Fill-the-Pot ...	2781·3	2071·2	710·1	761·52	918	9·45	6·39	12·24	4971·0	795	25·86	12·42	35·79
Fire Brass ...	7589·1	5429·1	2160·0	1939·77	2,202	12·90	11·37	31·11	7706·2	540	13·86	10·41	13·50
Honeychurch ...	4620·0	3000·0	1620·0	1445·61	1,662	10·17	9·69	21·72	9420·0	1,035	32·97	19·77	54·63
Hurley	10274·7	9632·4	642·3	3039·27	3,597	29·79	18·48	48·30	6421·5	900	29·55	12·84	25·05
Joe Mende ...	2603·7	1420·2	1183·5	876·93	1,041	10·14	3·90	10·41	4024·2	645	18·12	9·66	18·51
Johns	6625·8	4932·9	1693·0	1911·54	2,187	13·26	19·20	35·13	9223·8	1,476	35·97	18·45	48·90
Love Drops ...	6480·0	5195·7	1284·3	2508·42	2,982	22·02	11·67	15·54	10449·6	1,254	31·35	25·08	24·03

TABLE I.—SUMMARY OF CHIEF RESULTS.—(*Concluded.*)

Varieties.	Potatos. Total weight of potatos. Pounds per acre.	Weight of large.	Weight of small.	Starch. Pounds per acre.	Food units. Pounds per acre.	Nitrogen.	Phosphoric Anhydride.	Potash.	Vines. Weight of Vines. Pounds per acre.	Food units. Pounds per acre.	Nitrogen.	Phosphoric Anhydride.	Potash.
Minuet	9902·7	7111·5	2791·2	2833·17	3,366	25·74	21·78	41·58	10500·9	735	37·80	35·70	57·75
Moffard	11208·6	10099·5	1109·1	3284·13	2,802	25·77	16·80	29·13	9690·9	1,260	41·67	12·60	21·33
Red Bourbon ...	1049·1	740·7	308·4	310·80	366	3·15	1·47	3·36	8022·9	1,365	40·11	24·06	58·56
Red Sealy ...	6830·4	4611·9	2218·5	1980·12	2,322	18·45	13·65	22·53	8581·5	1,374	33·48	22·32	36·90
Trinidadian ...	5932·8	5011·2	921·6	1506·93	1,779	11·88	15·42	30·27	9705·6	1,164	33·96	28·14	44·64
Trinidadian (No. 1)	6978·6	4452·9	2525·7	1738·38	2,025	16·74	11·16	32·79	8374·2	1,173	64·47	22·62	41·88
Trinidadian (No. 2)	6646·2	4818·6	1827·6	2162·01	2,592	18·60	9·96	19·26	6563·1	1,050	28·23	13·14	19·68
Trinidadian (No. 4)	5832·0	5040·0	792·0	1260·30	1,458	11·67	9·90	22·74	10152·0	1,422	89·34	21·33	41·61
Vincelonian ...	7822·8	6421·8	1401·0	2641·77	3,129	23·46	14·85	24·24	3677·7	699	17·64	10·29	15·09
White Bourbon ...	5079·0	4203·3	875·7	1388·10	1,575	11·67	5·58	23·88	8581·5	1,458	28·32	25·74	51·48
White Gilkes ..	5644·8	4262·4	1382·4	1672·56	1,977	12·42	7·35	16·38	11980·8	1,317	32·34	33·54	46·74
White Gilkes (6 mos.)	11116·8	9849·6	1267·2	3590·73	4,002	17·79	15·57	36·69	10080·0	1,410	26·22	22·17	34·26
White Mary ...	1984·8	1342·8	642·0	654·60	795	6·75	3·36	6·54	4203·3	546	19·35	11·34	20·19
White Sealy ...	7530·9	6071·4	1459·5	2202·78	2,562	16·56	16·56	31·62	5487·6	879	25·80	13·17	21·39

TABLE II.—FIELD RESULTS.

VARIETIES.	Total weight of potatos in tons per acre.	Weight of large potatos in tons per acre.	Weight of small potatos in tons per acre.	Weight of vines in tons per acre.
Barker	2·82	1·69	1·13	5·91
Bequia	3·45	1·98	1·47	2·21
Blue Bird	1·31	·49	·82	4·93
Boot Heel	1·51	1·21	·30	2·65
Brass Cannon	3·49	3·15	·34	3·37
Caroline Lee	2·42	1·68	·74	2·75
Cover-the-World	3·21	2·66	·55	3·14
Fill-the-Pot	1·25	·93	·32	2·22
Fire Brass	3·39	2·43	·96	3·44
Honeychurch	2·06	1·34	·72	4·21
Hurley	4·59	4·30	·29	2·87
Joe Mende	1·16	·63	·53	1·80
Johns	2·96	2·20	·76	4·12
Love Drops	2·88	2·31	·57	4·67
Minuet	4·42	3·17	1·25	4·69
Moffard	5·01	4·51	·50	4·33
Red Bourbon	·46	·33	·13	3·58
Red Sealy	3·05	2·06	·99	3·83
Trinidadian	2·65	2·24	·41	4·33
Trinidadian (No. 1) ...	3·12	1·99	1·13	3·74
Trinidadian (No. 2) ...	2·97	2·15	·82	2·93
Trinidadian (No. 4) ...	2·60	2·25	·35	4·53
Vincelonian	3·49	2·86	·63	1·64
White Bourbon	2·26	1·87	·39	3·83
White Gilkes	2·52	1·90	·62	5·35
White Gilkes (6 months)...	4·97	4·40	·57	4·50
White Mary	·89	·60	·29	1·87
White Sealy	3·36	2·71	·65	2·45

TABLE III.—ANALYSES OF POTATOS.

VARIETIES.	Moisture.	Oil.	Albuminoids.*	Amides.†	Starch.	Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Barker	62·19	·93	·88	·33	33·17	1·08	1·42	100·00	·14	·06	·20	·16	·36	·58	39	29·3
Bequia	65·85	·50	1·31	·28	29·81	1·04	1·21	100·00	·21	·05	·26	·18	·37	·25	35	19·5
Blue Bird	66·00	·68	·56	·56	29·75	1·23	1·22	100·00	·09	·10	·19	·19	·36	·22	34	·28
Boot Heel	62·12	·23	1·31	·44	33·33	1·21	1·36	100·00	·21	·08	·29	·15	·39	·56	38	19·4
Brass Cannon	66·10	·38	1·75	...	29·65	1·00	1·12	100·00	·28	...	·28	·21	·23	·39	35	17·5
Caroline Lee	67·94	·37	1·25	·50	27·59	1·10	1·25	100·00	·20	·09	·29	·21	·13	·39	33	16·3
Cover-the-World	59·56	·59	1·75	·33	35·49	1·05	1·23	100 00	·28	·06	·34	·10	·18	·75	42	17·8
Fill-the-Pot	67·83	·26	1·81	·28	27·38	1·05	1·39	100·00	·29	·05	·34	·23	·44	·41	33	13·4
Fire Brass	70·89	·34	1·06	...	25·56	·92	1·23	100·00	·17	...	·17	·15	·41	·26	29	24·9
Honeychurch	64·28	·75	·56	·72	31·29	1·08	1·32	100·00	·09	·13	·22	·21	·47	·14	36	25·9

TABLE III.—ANALYSES OF POTATOS.—(*Continued.*)

VARIETIES.	Moisture.	Oil.*	Albuminoids.*	Amides.†	Starch.	Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Hurley	66·03	·42	1·19	·56	29·58	·92	1·30	100·00	·19	·10	·29	·18	·47	·42	35	17·5
Joe Mende	61·30	·26	1·63	·72	33·68	1·10	1·31	100·00	·26	·13	·39	·15	·40	·85	40	14·6
Johns	67·13	·41	1·00	·22	28·85	1·01	1·38	100·00	·16	·04	·20	·29	·53	·09	33	24·5
Love Drops	56·31	·69	1·44	·61	38·71	1·04	1·20	100·00	·23	·11	·34	·18	·24	·40	46	19·7
Minuet	66·83	·55	1·19	·39	38·61	·97	1·46	100·00	·19	·07	·26	·22	·42	·47	34	19·0
Moffard	66·76	·40	1·00	·39	29·30	1·05	1·01	100·00	·16	·07	·23	·15	·26	·31	25	15·6
Red Bourbon	65·52	·35	1·75	·11	29·62	1·09	1·56	100·00	·28	·02	·30	·14	·32	·50	35	16·4
Red Sealy	66·75	·38	1·13	·50	28·99	1·00	1·25	100·00	·18	·09	·27	·20	·33	·33	34	18·4
Trinidadian	70·50	·43	1·25	...	25·40	1·04	1·38	100·00	·20	...	·20	·26	·51	·28	30	21·2
Trinidadian (No. 1)	71·00	·33	1·50	...	24·91	·98	1·28	100·00	·24	...	·24	·16	·47	·36	29	17·1

TABLE III.—ANALYSES OF POTATOS.—(*Concluded.*)

VARIETIES.	Moisture.	Oil.*	Albuminoids.*	Amides.†	Starch.	Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Trinidadian (No. 2)	62·88	·67	1·75	...	32·53	1·05	1·12	100·00	·28	...	·28	·15	·29	·30	39	19·5
Trinidadian (No. 4)	74·22	·30	1·13	·11	21·61	1·17	1·46	100·00	·18	·02	·20	·17	·39	·44	25	18·0
Vincelonian	61·36	·76	1·88	...	33·77	1·13	1·10	100·00	·30	...	·30	·19	·31	·25	40	18·9
White Bourbon	68·81	·24	1·31	·11	27·33	·90	1·30	100·00	·21	·02	·23	·11	·47	·39	31	19·7
White Gilkes	65·96	·66	1·38	...	29·63	·99	1·38	100·00	·22	...	·22	·13	·29	·69	35	22·6
White Gilkes (6 months) ...	63·79	·65	·88	·11	32·30	1·09	1·18	100·00	·14	·02	·16	·14	·33	·31	36	34·2
White Mary	61·94	·62	1·63	·44	32·98	·99	1·40	100·00	·26	·08	·34	·17	·33	·53	40	16·7
White Sealy	66·87	·36	1·19	·17	29·25	1·01	1·15	100·00	·19	·03	·22	·22	·42	·06	34	22·2
Average ...	65·60	·48	1·30	·38	30·00	1·05	1·29	...	·21	·07	·28	·18	·37	·39	34·8	20·3

TABLE IV.—ANALYSES OF POTATO VINES.

VARIETIES.	Moisture.	Albuminoids.*	Amides.†	Starch.	Cellulose.	Woody Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Barker	79·36	1·44	·67	1·33	7·16	6·21	3·83	100·00	·23	·12	·35	·27	·44	1·22	14	4·0
Bequia	78·15	2·63	·17	...	8·22	6·65	4·18	100·00	·42	·03	·45	·25	·33	1·35	15	2·9
Blue Bird	82·55	1·75	·61	·04	6·85	5·32	2·88	100·00	·28	·11	·39	·22	·37	·59	13	2·9
Boot Heel	77·43	2·25	·39	·32	9·74	6·19	3·68	100·00	·36	·07	·43	·26	·53	·87	17	3·8
Brass Cannon...	81·96	2·31	·78	...	6·84	5·39	2·72	100·00	·37	·14	·51	·22	·28	·58	15	2·2
Caroline Lee	76·93	2·44	·44	1·01	7·69	6·72	4·77	100·00	·39	·08	·47	·32	·63	1·13	16	3·0
Cover-the-World	78·95	2·06	·11	...	7·33	7·38	4·17	100·00	·33	·02	·35	·23	·58	1·93	13	3·4
Fill-the-Pot	82·32	2·75	·44	3·46	4·50	3·15	3·38	100·00	·44	·08	·52	·25	·72	1·21	16	2·5
Fire Brass	79·92	2·25	...	2·93	5·86	5·46	3·58	100·00	·36	...	·36	·27	·35	1·03	14	3·9
Honeychurch	82·39	1·63	·50	...	6·01	6·52	2·95	100·00	·26	·09	·35	·21	·58	1·24	11	2·8

TABLE IV.—ANALYSES OF POTATO VINES.—(*Continued.*)

VARIETIES.	Moisture.	Albuminoids.*	Amides.†	Starch.	Cellulose.	Woody Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Hurley	82·07	1·69	1·06	·51	6·56	4·62	3·49	100·00	·27	·19	·46	·20	·39	·82	14	2·6
Joe Mende	79·77	1·88	·83	2·47	6·92	8·13	...	100·00	·30	·15	·45	·24	·46	1·33	16	3·5
Johns	78·03	2·19	·22	3·35	6·87	5·32	4·02	100·00	·35	·04	·39	·20	·53	·86	16	4·2
Love Drops	80·73	1·75	·11	1·06	5·89	6·69	3·77	100·00	·28	·02	·30	·24	·23	1·21	12	3·7
Minuet	90·32	1·75	·44	...	1·17	2·91	3·41	100·00	·28	·08	·36	·34	·55	2·03	7	·5
Moffard	82·47	1·75	·83	1·02	6·00	5·28	2·65	100·00	·28	·15	·43	·13	·22	·79	13	2·7
Red Bourbon	78·75	2·00	1·00	1·73	7·29	5·51	3·72	100·00	·32	·18	·50	·30	·73	·81	17	3·0
Red Sealy	77·82	2·44	...	4·27	5·78	6·01	3·68	100·00	·39	...	·39	·26	·43	·89	16	4·1
Trinidadian	81·56	1·88	·28	1·81	5·25	6·38	2·84	100·00	·30	·05	·35	·29	·46	·66	12	3·3
Trinidadian (No. 1)	84·48	2·00	2·50	...	2·83	4·93	3·26	100·00	·32	·45	·77	·27	·50	1·39	14	·6

TABLE IV.—ANALYSES OF POTATO VINES.—(*Concluded.*)

VARIETIES.	Moisture.	Oil.	Albuminoids.*	Amides.†	Starch.	Fibre.	Ash.‡	Total.	*Containing Nitrogen.	†Containing Nitrogen.	*†Containing Total Nitrogen.	‡Containing Phosphoric Anhydride.	‡Containing Potash.	‡Containing Sand.	Value in Units.	Albuminoid Ratio 1 to
Trinidadian (No. 2)	78·94	2·56	·11	3·47	6·16	5·09	3·67	100·00	·41	·02	·43	·20	·30	1·09	16	3·6
Trinidadian (No. 4)	85·93	1·50	3·56	...	·97	4·29	3·75	100·00	·24	·64	·88	·21	·41	1·51	14	·2
Vincelonian	75·91	2·56	·39	2·59	8·63	5·66	4·26	100·00	·41	·07	·48	·28	·41	1·34	19	3·8
White Bourbon	76·82	1·88	·17	5·69	5·79	6·01	3·64	100·00	·30	·03	·33	·30	·60	·62	17	5·6
White Gilkes	82·53	1·63	·06	·11	7·03	4·50	4·14	100·00	·26	·01	·27	·28	·39	1·23	11	4·2
White Gilkes (6 months) ...	79·22	1·38	·22	4·02	5·86	6·08	3·22	100·00	·22	·04	·26	·22	·34	·85	14	6·2
White Mary	79·18	2·88	...	..	6·02	8·34	3·58	100·00	·46	...	·46	27	·48	1·05	13	2·1
White Sealy	77·65	2·69	·22	3·51	5·22	7·24	3·47	100·00	·43	·04	·47	·24	·39	1·19	16	·3
Average	80·43	2·07	·64	2·24	6·09	5·79	3·58	100·00	·33	·12	·45	·25	·45	1·10	14	3·2

THE FRUIT INDUSTRY OF JAMAICA.

The following is a report on the Fruit Industry of Jamaica by Mr. W. E. Smith, General Manager, Trinidad Government Railway, who recently paid a visit to Jamaica as a special representative of the Trinidad Agricultural Society. Mr. Smith's report was published as Paper No. 213 in the *Proceedings* of the Society. It furnishes a useful supplement to the valuable paper by the Hon. Wm. Fawcett, B.Sc., F.L.S., Director of Public Gardens and Plantations at Jamaica, on the Banana Industry in Jamaica, which was read at the Agricultural Conference at Barbados in 1902, and published in the *West Indian Bulletin*, Vol. III., p. 153:—

Had I confined my investigations to the mere handling and transporting of fruit, I should have had a comparatively short and easy task, for the reason, principally, that very few shipments were being made during the time I was in Jamaica, in consequence of the hurricane last year having retarded the crops in most of the big banana districts. The opportunity was therefore afforded me of seeing much else that was interesting and instructive, both with regard to the cultivation, and the general development of this remarkable industry in our neighbouring colony. I purpose including in this report a few out of the many such notes and observations I was enabled to make, my object being to interest those who are already taking, or intending to take, some active share in the establishing of such an industry here in Trinidad.

The value of the fruit exports of Jamaica exceeds one million pounds sterling, annually, or over 60 per cent. of the total exports of the colony. Nearly seven-eighths go to the United States, and the remainder to the United Kingdom and other British possessions.

It is estimated that 33,000 acres are under banana cultivation, comprising 240 estates or thereabout, varying in acreage from twenty to five and six hundred, and hundreds of small settlers scattered far and wide, with holdings of less than 20 acres. During the past five years the shipment of fruit from Jamaica has just about doubled itself. Last year the total number of bananas grown and exported was in the neighbourhood of eight million bunches.

The largest areas of cultivation lie in the valleys and slopes along the seaboard, but there are also plenty of estates in the hilly districts, and in the 74 miles railway journey from Kingston to Port Antonio, bananas are everywhere to be seen. The route lies for many miles over a stiff mountain range, and on all sides there were small patches of bananas.

Even in the crevices of rocks, healthy plants were growing and thriving upon the rich wash mould to be found thereabout.

Upon the plains, too, on the southern side of the island, old abandoned cane lands have been transformed into luxuriant banana groves, yielding, by the aid of irrigation, 300 bunches to the acre.

There is, I am informed, a great variety of soil in Jamaica—good, bad and indifferent. In some districts little manuring is done, and in others a considerable amount is necessary. To supply this demand a great deal of stock is kept, which, combined with banana growing, seems to be a most profitable business for big and little man alike.

High cultivation is aimed at, as evidenced by the absence of undergrowth in most places I saw; but labour difficulties are just as prevalent with them as with us. Ploughing, harrowing and forking, both before and after planting, are universally practised, and the benefits of good drainage appear to be of first and foremost consideration. In short, the whole object is to produce the biggest crop possible, and the finest fruit, for upon these, and the most careful handling, hangs the entire success or failure of banana growing.

The handling and transporting of ripe fruit are perhaps the greatest difficulty both growers and shippers have had to meet and are still contending with. So watchful are the shippers, and so stringent their rules, that it is now well nigh impossible for an unripe or even slightly bruised bunch to be accepted at any of their dépôts.

Consequently the growers, great and small, being very much alive to their own interest, take exceedingly good care to ensure compliance with the buyer's requirements, inexorable as they be. A methodical system of tally and supervision prevails on the larger estates, whereby careless handling may be promptly brought home to the offending labourer or carter, and by these means all classes are becoming educated to the knowledge that care pays in the long run, and wanton neglect brings almost certain loss to the individual.

The finest and best-conditioned fruit invariably commands the topmost price, and preference is always given to really cultivated bananas, long experience having shown (so I was told by one of the principals of the United Fruit Company) that they are by far the best carriers.

VARIETY OF BANANA GROWN.

As to variety, there is only one in Jamaica and it is called by the generic term of 'Banana' or 'Fruit.'

It is of course the 'Martinique' or 'Gros Michel' sort known to Trinidad growers. An inconsiderable quantity of the red variety is also grown in Jamaica, and is occasionally shipped away, more as a decorative fruit than anything else, realizing fancy prices. The smaller kinds of 'figs' I saw very few of in any part of the colony; and the banana of commerce was not in my opinion superior either in size or in flavour to our ordinary 'Gros Michel' in Trinidad. With regard, however, to the size of the average bunch (i.e., the number of 'hands') there can be no question that ours are inferior. I am judging merely by Mr. Symington's shipments; but there is, I believe, no reason whatever why, with proper cultivation, the size of bunches of bananas grown in Trinidad should not rival, and even eclipse, those produced by any of our neighbours.

METHOD OF PURCHASE, SIZE OF BUNCHES, PRICE, ETC.

Upon this question of 'size' I will afford a few particulars of the regulations that have become the recognized standard in Jamaica for buying and selling. A full bunch or 'straight,' as it is technically known, consists of nine hands or better. Eight hands count as three-quarters, seven hands as a half, and six hands as a fourth. Abnormal bunches of fourteen and fifteen hands are generally subject to higher prices by arrangement.

At first glance, the advantage of this method would seem to be all on the side of the buyer, but in effect it is not so, being more or less mutual.

Big bunches mean better fruit, more convenient handling and safer carriage, also higher prices from the wholesale dealer. These the shipper requires, and pays his premium for getting. He does not want small and inferior specimens, and will only take a limited proportion of them in any case.

On the other hand, the grower cannot, under the most favourable circumstances, avoid a certain percentage of small bunches, and he is quite satisfied to sell them at the reduced rates referred to. The fruit cut from young plants is usually undersized.

Patches of inferior land and unfavourable situations produce similar results, and from a variety of causes the planter is obliged to reckon upon a proportion of low grades in his annual crop. At any rate, the arrangement seems to work all right in Jamaica and is generally considered to be perfectly equable. Its reaction upon the cultivators is, moreover, far-reaching and beneficial, inasmuch as it forces upon them the all-important necessity of good tillage, intelligent management and careful handling, as the only means of realizing satisfactory returns.

The prices paid by buyers and shippers vary according to the season, and the exigencies of supply and demand.

For the English market, the best prices are obtainable in the summer and autumn months, and for the United States, from April to August.

So far as I was able to ascertain, the highest figures reach £12 10*s.* per 100 bunches, and the lowest £5, the average being £7 10*s.*, or 1*s.* 6*d.* per bunch of nine hands. Delivery in all cases to be made at the nearest dépôt or railway station.

The large exporters enter into agreement with the growers to take fruit all the year round at a fixed scale of prices.

Penalties are enforced in the event of failure to supply the stipulated quantities, and the business is worked under a splendid organization. It is nothing uncommon, in the height of the season, to load a dozen large steamers in a week with fruit drawn from every part of the island.

These large buyers are connected by telephone and telegraph with their various agents all over the colony, and a few hours' notice suffices to cut, transport and load a ship with 30,000 to 40,000 bunches. One estate I visited had a few miles

of its own tramway, and the proprietor told me that his fruit was usually alongside the ship four hours or so after cutting. Where much heading out and cartage has to be undertaken, the operations are necessarily more tedious and costly, but the prices paid for good sound fruit allow of a very fair margin, and (excepting in the case of standing agreements) payments are invariably made straight on delivery. The cultivation of bananas is consequently widely taken up by the peasant classes, who appreciate, more than anyone, quick returns for their labour.

NECESSITY FOR GOOD ROADS.

The average distance over which bananas have to be headed, crooked and carted in Jamaica is certainly not less than it would be in Trinidad, while the physical difficulties to be overcome amid their mountains and deep valleys are incomparably greater than with us. It is true that they have an excellent system of main and parochial roads, also bridle tracks, extending over the length and breadth of the island, but even with these advantages, journeys to the railway and seaboard are by no means easy or short. Jamaica is a biggish place, being about two and a half times the size of this colony, and nearly 2,000 square miles of its total area lie 1,000 feet or more above sea-level.

In Trinidad, the want of good and sufficient roads into some of the interior districts is a serious drawback, no doubt particularly during the rainy season ; but it must be admitted that these deficiencies, which are slowly but surely disappearing, are confined to but a comparatively small portion of the settled and partly developed lands of the colony.

BANANA CULTIVATION.

Everything considered, I venture to state that the natural conditions here, including rainfall, all favour profitable banana growing, and we are happily not liable to hurricanes such as swept the standing crops to the ground in Jamaica last year.

There is striking proof of the adaptability of our soils and climate in the luxuriant growth of bananas to be met with in all directions, and on all varieties of land, many of them growing and thriving in a practically wild state.

The selection of soils and situation, the season for planting bananas, and many other things, connected with the practical side of the subject, are matters that must necessarily be left to our experienced agriculturists. I do not know whether any treatise on banana growing has ever been published in the Bulletins of the Royal Botanic Gardens. Very possibly one or more have, and should this be so, a reprint would be of value just now. A paper on 'The Banana Industry in Jamaica,' prepared for the Agricultural Conference in Barbados, January, 1902, is printed in pamphlet form, and its pages afford a very useful amount of information.*

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* Published in the *West Indian Bulletin*, Vol. III, no. 2.

It supplies the alpha and omega of banana culture, and ought to be read by all those interested in the industry.

The several examples therein given of the debit and credit side of things agree with my own observations, and the particulars I personally obtained on the spot.

COST OF CULTIVATION.

One estate I visited afforded some very interesting details. It consisted of 300 acres of converted cane land principally, and had been in cultivation about three years.

The cost of cleaning and preparing the land, ploughing, planting, weeding and pruning was a little over the average of £10 per acre. The initial expenses were fully realized with the first fruiting, after which, the net clearance each year amounted to not less than £10 per acre. This is typical of many estates, both where irrigation is carried on and otherwise. It is a simple calculation. An acre of bananas planted, say 14 feet by 12 feet, will give roughly 250 plants, or three stems to each stool. Under good tillage, and with average luck, these should produce not less than 300 bunches annually, extending over the ratooning period, which varies from three to six years. To be on the safe side, suppose we say 260 full paying bunches, which realize the average price of 1*s*. 6*d*. The gross revenue comes to £19 10*s*., and after deducting, say, 45 per cent. for general management, including propping the fruiting stems, reaping, carting, and interest on capital, the net clearance is £10 per acre and not less. It is generally conceded that 100 acres of bananas in full bearing, under average conditions of soil cultivation and rainfall, mean an income of £1,000 a year. This of course applies to Jamaica where the market for bananas is certain and steady. In specially favoured districts and irrigated lands, the profits are much higher, and when stock keeping is combined with cultivation, or where young cacao and other products are interspersed between the bananas, there must obviously be a much wider range for profitable speculation than could possibly be found in any other farming industry known to the West Indies.

PROSPECTS FOR BANANA CULTIVATION IN TRINIDAD.

To describe in detail all that I saw and learned with regard to planting and treatment of growing crops, would be travelling even farther than I have already gone outside the real object of my mission to Jamaica. I saw sufficient to convince me that we have a very great deal to learn from our neighbours in that colony, but of course they have been twenty years or so at the business, and bananas to them have been, and are, what cacao at present prices is, and will be (so long as those prices continue), to many of our planters and small settlers.

It remains, however, to be seen whether the latter could not advantageously plant the 'Gros Michel' more generally than is now done, as shade for young cacao, and I am quite sure that with capital and enterprise there are (exclusive of Tobago) thousands of acres of idle lands within 20 miles of Port-of-Spain—much of it conveniently served by roads

and railways —that might profitably be taken up for bananas alone.

Should cacao ever touch, say, 45*s*. and stay there awhile, no further argument would, I imagine, be necessary; and the world's production is increasing so enormously, that in the natural sequence of such things there is bound to be a gradual but certain levelling of the prevailing average prices as time progresses.

IMPORTANT LESSONS LEARNED IN JAMAICA.

The important lessons they seem to have learned in Jamaica may briefly be summarized as under:—

(1) Thorough preparation of the land before planting, good drainage and free use of the plough, fork and hoe afterwards. In other words, nothing but high cultivation pays in the long run.

(2) Planting at such time only, and pruning of suckers, as will ensure fruiting and proper rotation, during those months when the highest prices prevail.

(3) Religious care in cutting, handling and transporting the ripe fruit, without which everything else counts as nothing.

CUTTING, HANDLING AND TRANSPORTING BANANAS.

The process of cutting, handling and transporting is one of unceasing care and anxiety. The stem is cut on the top, just below the head, when the bunch topples over and is caught by a second helper. It is not allowed to fall to the ground. A sharp machete or cutlass does the requisite trimming, and the refuse is afterwards chopped up and left on the soil. The remaining stump is allowed gradually to rot from the top, which admits of the heavy amount of sap it contains being slowly returned to nourish the young sucker at its root.

Following this, the bunches are roughly graded and tallied, and headed out to some convenient place and there packed in trash to await the later removal to the nearest railway station or shipping dépôt.

All this is done under the eye of an experienced overseer.

Donkeys are used for carrying the bunches crook fashion; and where carting has to be performed, the fruit is carefully stowed in the vehicles, trash being used to prevent bruising and chafing.

It is a crime for any person even to attempt to accommodate himself on the top of a load of bananas in transit.

The wagons and carts generally used are made with springs, and are fitted with high sides and ends, as light and open as possible. A fuller description of these conveyances will be given further on. When the journey has to be performed partly by rail, the bananas are brought to the station and transferred to the wagons with the same amount of watchfulness and care as before. Trash is again used, and

the work of loading is undertaken almost entirely by the buyer's agents.

RAILWAY CHARGES.

In Jamaica, railway freights are generally paid by the shippers, as they doubtless would be here, and such charges are very considerably in advance of those contemplated in this colony.

Their scale is as follows :—

> Full car loads, carrying from 300 to 750 stems each—15*s*. 2*d*. to 26*s*. 10*d*. per 100, up to 32 miles (including wharfage and shunting charges of 1¼c. per bunch), equal to 4¾c. per bunch, average distance.
>
> When sent in less than car loads, 2*s*. per 100 must be added to the above, which brings the freight to about 5¼c.

I have confined these particulars to the 32 miles freightage, as approximating more closely to our local circumstances, but it will be obvious at once that, if 5¼c. be the mean, the railage cost, when, say, 20, 30 or 40 miles are reached, becomes a rather serious calculation in Jamaica.

Yet the industry thrives there, and the railways are owned and worked by the Government. So far, in Trinidad, we have loaded, carried and delivered bananas alongside the wharves for 3c. per bunch, experimentally, I may add, and irrespective of quantity, large or small.

I heard of no such thing as free carriage of fruit in Jamaica, nor of any other, direct, artificial aids to the growers.

There is, however, a system of agricultural instruction provided by the Government, and a great deal of practical demonstration of the right sort is thereby brought home to the small agriculturists all over the island.

LOADING AND CARRIAGE BY STEAMERS.

Of the actual performance of putting bananas afloat I am unable to speak from personal observation, for reasons already explained. The whole process was described to me by the United Fruit Company's people, and its main features consist in heading and shouldering the stems from the sheds on the wharves into the holds of the ship—combined with the smart work done by the expert checkers, under whose eyes every individual bunch undergoes a final inspection. These fruit vessels also pick up round the coast, and the bananas have then to be handled from shore to ship in boats of various kinds.

In the United Fruit Company's steamers the fruit is stowed on simple racks or binns, without any trash whatever, and the holds are specially ventilated only. The comparatively short voyage of four and a half to five days does not call for any other treatment, but with the Imperial Direct Line to Bristol, and the Elder & Fyffe's boats to Manchester, cool storage on the most approved principle is provided.

I do not think that many Jamaica bananas are crated.

A system of care, that is never relaxed from start to finish, would seem to take the place of any such precautions, which are not only costly, but go to reduce the carrying capacity of the ship's holds.

I was told that in vessels, properly installed with cool chambers, no crating is necessary, not even trash.

TRANSPORTATION OF BANANAS.

During my visit to Jamaica, I made some useful notes and comparisons with reference to the conveyance of fruit over the Government railways there, and without going into details at this moment, I may say at once that I see no special difficulty in affording all the conveniences necessary for handling a large traffic here whenever the demand arises.

The question of the kind of carts used upon the roads also received some attention, and, at your request. I visited the firm of Messrs. Cordova & Brown, in Kingston, for the purpose of examining their specialties. The four-wheel waggons as well as the two-wheel carts are admirably adapted, I consider, for our country roads. The former will accommodate as many as 150 stems of bananas, equal to 3 tons, and the carts about a third of that quantity. These vehicles are light and exceedingly strong. I enclose three photographic drawings of them, together with the final offer of the firm. The prices, f.o.b. at Kingston, are £26 and £10 for the waggon and cart respectively, and if it could be arranged to get a pair of them over, as examples, and offered locally at cost, I dare say ready purchasers would be forthcoming.

The vehicles are designed for general purposes as well as for the conveyance of fruit, and for long cartage of cacao in our country districts they would be a great improvement upon the description of cart in common use here.

PURCHASE OF SUCKERS.

With regard to the question of purchasing suckers, I made inquiry in all likely directions, and finally, by the aid of the Hon. W. Fawcett, the Director of Public Gardens and Plantations, (to whom I am indebted for many other acts of kindness), I was enabled to close with an offer of 8*s.* per 100, delivered packed on the Royal Mail Wharf, subject to inspection before shipment.

Captain Constantine has also been taking a personal interest in this matter, and is giving all the facilities in his power, including a special through rate of 2*s.* per 100. These suckers are being obtained from the hilly districts, which Mr. Fawcett considers is an advantage, on account of their hardiness.

A trial shipment was to come forward by the R.M.S. 'Trent' and it is probable that the cost, landed in Port-of-Spain, will be nearer 10*s.* than the 15*s.* previously contemplated. You will probably delay any further shipments just yet, seeing that the dry season is at hand. The United Fruit Company was prepared to supply any number of suckers at 10*s.*, f.o.b the coastal steamer, to which would have to be added another 2*s.* for transhipping and packing in Kingston. This seems to be the fixed price in all

quarters and the offer of 6*s.* 3*d.*, which you received from a Mr. Dill, meant delivery at Albany station, 40 miles up country, and when railage and cartage to wharf in Kingston were paid, the total expense would come to about the same thing, viz., 10*s.*, exclusive of packing.

CITRUS FRUITS, PINES, ETC.

I have dealt so far in my report with the banana section only of the fruit industry of Jamaica, believing that this is more likely to command the greatest share of our attention in Trinidad. Oranges, grape fruit and pines, however, figure in no insignificant degree in the total value of their exports.

During last year they shipped nearly 71,000,000 oranges, equal to 180,000 barrels, 8,011 packages of grape fruit and 8,220 dozens of pines. The railway freights realized £14,348 from oranges and grape fruit in the same period. The scale of charges varies from 6½*d.* to 1*s.* 2*d.* per barrel up to 32½ miles, which is more than double the present and probable railage cost in Trinidad, for even small quantities. It may be interesting to note here that, in addition to the above, the railway revenues from banana traffic in Jamaica totalled the respectable sum of £26,306, covering the last financial year.

The Jamaica oranges possess a very fine texture and exquisite flavour, but they are in my opinion inferior in size and appearance to those ordinarily grown here, while the best of our varieties would be hard to beat anywhere.

The greater proportion is sent to the States, but of late years considerable quantities have been put on the English market, and found much favour there.

Notwithstanding a protective duty of $1·50 per 70 lb. gross in the States, it seems that the Jamaica growers can still make a profit out of oranges so long as the Florida and California fruit is not in season. It is to the English markets that the buyers are at present looking, but the general complaint is want of more frequent shipping facilities than are afforded by the fortnightly service to Bristol by the Imperial Direct Line.

Several planters told me that, if the Royal Mail would fit their steamers with cool storage, regular use would be made of that route, thus giving them a weekly opportunity, alternating with the Elder Dempster boats.

The large buyers of oranges pay from 1*s.* per 100 to as low as 3*d.*, delivered at the nearest railway station, and the process of grading, wrapping and packing is done very much in the same manner as that followed by the Symington Syndicate here. The prices realized in English ports are subject to great variation, according to quality, condition and season.

Last Christmas the best quality of Jamaica oranges fetched in London from 12*s.* to 14*s.* per box of 200, a statement I should myself scarcely credit, were it not taken from a very reliable source indeed.

On all sides I heard the same story, that profits or losses (as with bananas) depend absolutely upon the kind of care given to the selection and handling of oranges before shipment,

and to the maintenance of an equable temperature throughout the sea voyage.

Quality and condition, as with most things, will always command and hold the best markets, and the Jamaica people seem to be fully alive to this.

Budding of the choicer sorts is practised to some extent, and hybridizing experiments are also being carried out with the Ripley and Cayenne varieties of pines, the special object being to combine the superior edible qualities of the one with the more symmetrical shape and size of the other.

CONCLUDING REMARKS.

In concluding this report, it is fitting perhaps that I should offer some explanation of its length and divergence from the original text of my instructions. This fruit industry presented at every turn so many other interesting and instructive features more or less connected with transporting arrangements, that I considered it would be a profitless use of time and opportunity, did I not enlarge somewhat the scope of my observations and inquiries.

Through the courtesy and ready assistance given to me by the Government, including the Director of Public Gardens, the Director of the Railway, and the Secretary of the Agricultural Society, I was at once placed in touch with some of the leading planters and large shippers of fruit, and though my time was limited, and distances in Jamaica are long, I had, in a variety of ways, exceptional opportunities for observing things, and acquiring information in the most reliable quarters.

The impressions given in this report are those left upon a perfectly open mind, though I am fully conscious that in expressing opinions and offering suggestions, with regard to the purely agricultural side of the question, I have been occupying both delicate and unaccustomed ground.

I am nevertheless convinced that the growing of bananas for the English and American markets might profitably be undertaken in this colony, disregarding altogether the examples I have quoted of profits made in Jamaica. Personally, I should be satisfied to take those figures at 50 per cent. discount, when there would still be left a net yield of £5 per acre. It is an axiom in Jamaica that nothing responds so readily to good cultivation as bananas, and over a short series of years an average estate will give *just about double what is spent upon it*, all other things being equal.

The development of the industry here will have to be taken in hand on a large scale, if the Royal Mail (or any other Steamship Company) is to be expected to fit ships with modern fruit storage, and afford regular sailings. It is either that or nothing.

The transhipment of bananas from lighters and coastal steamers into the ocean ships, while increasing the cost but very slightly, and necessitating extra precautions, need hardly enter into the growers' calculations, seeing that those services and risks will belong exclusively to the buyers and shippers.

To keep pace with the small and irregular crops that would come forward during the first year or so of the establishing of the industry, arrangements would have to be made for adequate cold storage on the Royal Mail Ocean Steamers at least once a month, in order that sales might be realized, and to prevent disappointment at the outset. And in this connexion, two of the Trinidad Line boats have already a limited accommodation for carriage of perishables, and it might be possible to get the Shipping and Trading Company to offer an outlet in the direction of the New York markets.

If the growing of fruit on any substantial and lasting scale is seriously taken up by the people of this colony, it will be deserving of, and will doubtless receive, in its initial stages, at any rate, every material assistance the Government can reasonably give to it; and if I may be permitted to make a final suggestion, it is that his Excellency the Governor might be approached with a proposal to sanction, say, 100 acres of St. Augustine lands being laid down in bananas, under the direct control of the Manager of that estate, to be followed later on by offers of other suitable lands in that district and elsewhere to large and small capitalists, on easy and attractive terms, for the same specific purposes.

I can conceive no more useful nor certain way of preserving and stimulating the interest that has already been aroused by Mr. Symington and his influential syndicate in this important though long-neglected industrial resource of the colony.

THE LEMON INDUSTRY IN SICILY.

In the following pages valuable information will be found relating to the Lemon Industry in Sicily.

The information was obtained at the instance of Mr. H. Hesketh Bell, C.M.G., Administrator of Dominica, to whom a letter, dated November 17, 1902, had been addressed on the subject by Mr. J. W. B. de Souza, a prominent planter in Dominica. In his letter to the Administrator, Mr. de Souza stated that he had been informed by his agents in London that the fall in prices of concentrated lime juice and by-products had been due to the over-stocking of the market by similar products obtained from lemons deteriorated by the cyclone in Sicily, which would otherwise have been shipped as green fruit. Mr. de Souza, therefore, requested the Administrator to obtain information on the following points:—

(1) Whether the cyclone had been prejudicial (a) only to the standing crop, and to what extent; (b) or also to the plantations themselves, and to what extent; and (c) what hopes were entertained for the following crop?

(2) The total acreage under cultivation in each locality as well as the yield per acre, in fruit, juice, citrate or oil.

(3) The cause of the preference given in the London market to Sicilian concentrated lemon juice over West Indian concentrated lime juice.

As a result of Mr. Hesketh Bell's communications, the Secretary of State for Foreign Affairs was requested to cause further information to be obtained through His Majesty's Consul at Palermo.

The following is an extract from the *Report on the Trade of Palermo and district of 1894*, issued by the Foreign Office as No. 1,544 of the Diplomatic and Consular Reports, pp. 16-21 :—

GREEN FRUIT.

So-called from their being gathered when yet green, in order to stand the voyage. Both oranges and lemons grow abundantly in the Provinces of Palermo, Messina, Catania and Syracuse ; Messina is especially noted for lemons. The best oranges are those grown in the Province of Catania, especially at Aderno and Biancavilla, but very many excellent and mixed qualities are found in the province of Palermo. They are distinguished as ordinary, blood, and sweet or vanilla, and mandarines. Lemons present no variety although they have designations known to the trade. Shipments mostly go to the States.

Boxes and cases are spoken of as 16, 25, 30, 36, 42, 49, etc., according to the number of oranges or lemons in each layer. The fruit that goes to the United Kingdom is in cases, and that for the United States in boxes and half-boxes. They are carefully stowed in tiers, one above the other, in the vessels' hold, in such a way as to prevent injury to the fruit. Half-boxes only contain two layers of fruit ; boxes, four and sometimes five. All, whether oranges or lemons, are wrapped in tissue-paper, with paper shavings to fill up interstices, and ripen on the voyage. Naturally this fruit can never be as good as that which ripens on the tree. During the last few years fears have been entertained that this trade to the States will eventually suffer considerably on account of suitableness found in the climate and soil of Florida and California, where the trees have been extensively introduced. It follows that if the States can produce their home supplies, there will be little or no demand for fruit from here, and with their system of railways, their markets will be supplied with fresh fruit which has not run the risk of deteriorating on a long sea voyage. Unfortunately, the orange crop in Florida was destroyed by the exceptionally severe cold experienced in December last. This will occasion an advance of prices in the States, the effect of which will be to stimulate the trade in Sicily in 1895.

The growth of this trade has only been developed within the last forty years, and since the introduction of steam it is four times or more as great as it was in the days of sailing craft. Commensurate with this increasing demand and prompt disposal of cargoes, the value of fruit in this country has been

enhanced and this consideration, in the words of my report of 1893, induced growers to raise their prices, and there followed temporarily a marked decrease in the demand. Fruit then was shipped at exporter's risk and this failed to answer; agents were sent over to the States to safeguard exporter's interest, as it was thought, but even this measure was ineffectual, for it was found that the former induced shippers who had not their own agents in the country to send their supplies to them, under promise of greater facilities, etc. In this emergency the questionable system of money advances to shippers sprang up, in order to secure shipments, and fruit began to be put on board unfit to stand the voyage.

Shipowners, in some cases, are known to have entered into contracts with shippers for certain supplies to be put on board their vessels during the fruit season in consideration of this advance to be accounted for on settlement of freight.

CULTIVATION OF ORANGE AND LEMON TREES.

The following practical notes regarding the cultivation of orange and lemon trees will, it is hoped, answer the many inquiries addressed to me. The fruit is one of the chief articles of trade in Sicily. In some parts of the island they are a source of wealth to the proprietor and afford work to thousands of men, women and children in cultivating the tree and in gathering and packing the fruit for exportation. Besides, there is work in the production of essences whether of orange, lemon, mandarine, or bergamot, and concentrated lemon juice: the latter is carried on on a large scale. Vice-consul Elford, who furnishes me with all particulars, correctly observes that the lemon is the most productive as well as the most remunerative of the class and gives the largest return per acre of land planted. The trees are set about 5 yards distant one from the other in rows and equidistant. Stony or sandy soil is apparently the best suited, for the best groves are near the beds of torrents or on the coast line from Messina to Acircale, for instance, and from Milazzo to Messina, and in the neighbourhood of Palermo. They will not thrive in a stiff soil, such as clay, for roots are superficial aud abundant. The trees have to be well manured, at least once a year, and the way is to dig a trench, say, about 40 inches from the stem and bury the manure 18 inches below. Ripe stable mixed with wood ash and bone is said to yield the best and fetches the highest price. Mr. Elford points out that the blossoms of April produce the best fruit, known as primo-fiore (choice fruit), which is gathered in October, and those of May yielding a second crop, gathered in November and December, are the best crops as well as the most abundant, and upon them proprietors base all their calculations. The blossoms of June produce fruit gathered in January and February, those of July generally fall off and little heed is taken of them, those of August are gathered in March, those of September produce a better fruit, gathered in April and May; the fruit of those of October, November and December are known as bastards and are gathered in June, July, August and September, whilst those of

January, February and March yield little fruit, which falls under the same denomination.

The first gathering occurs in October, care being taken that the lemons be not less than 3 inches in circumference; all under are left for the November gathering. Practised hands gauge the fruit with thumb and second finger. The first crop (the most valuable) is carefully selected, packed, and shipped off for early spring or summer use, and realizes 30 per cent. more than any subsequent gathering; no time, therefore, is lost in sending it off as early as possible, in order to get the highest price. As I have already observed, they are packed in variously sized cases to suit the different markets. Those for France are of one size, those for London of another. Each case contains about 450 lemons. For the States and Trieste boxes are used, containing only about 360. All that are considered inferior are put in small cases for the Italian market, and fetch 40 per cent. less.

SECOND GATHERING.

The second gathering takes place in November, and is as good as that of October, and will keep for months in boxes, if properly selected and packed; it is paler in colour, and harder to the touch. It is, therefore, often kept in cases until March, then repacked, and keeps good for a reasonable time. This chiefly goes to the States and Russia. All small or damaged fruit, which must not be left on the tree, is collected and used for making essence from the peel, and concentrated juice from the pulp. The custom is to calculate 104 kilograms of this inferior fruit as equivalent to 1,000 lemons, and charge 30 per cent. less than for the good box fruits. Of all the inferior fruit, that gathered in November is considered the best for the making of essence and lime juice, because it contains more valuable properties, yielding 50 per cent. more than that of other months. One thousand of these give about 16 oz. of essence and 35 litres of raw lemon juice, which, after concentration to the normal standard of 64 oz. of citric acid per imperial gallon, is reduced to $3\frac{1}{2}$ litres. On a well-cultivated plantation results show that seven-eighths of November fruit is good for shipment, and only one-eighth for essence and lime-juice.

The fruit gathered in December is considered inferior, as only five-eighths is fit for exportation, and three-eighths go for making essence and lime juice. It is packed in small cases for the States, Southern Russia and Trieste, and is worth about 15 per cent. less than the same sized cases of November fruit. Also the percentage of essence is about 15 oz. less per 1,000, and the juice about 14 litres more. After the juice is expressed, the residue is given to the goats.

The January fruit, again, is inferior to that of December, only three-eighths being fit for packing; the rest is used for juice and essence. This fruit is perfectly yellow. Such as is fit for exportation is packed in boxes, the same as that of December; that which is not, is cut and pickled in casks

with salt, and then exported. Each cask contains about 3,400 lemons.

February's fruit is the last of the season: it is also called the 'old fruit,' because the remains of previous gatherings. Nothing is now left on the tree except the green fruit of the August blossom. Of this crop only two-eighths can be packed for shipment, which on arrival have to be sold at once, as they will not keep. The remainder are used for essence, juice and pickling, and yield about 12 oz. of essence and about 42 litres of raw lemon juice.

COST OF EXTRACTING ESSENCE.

It costs about 1*s.* 4*d.* to extract the essence of 1,000 lemons, and £4 to make a cask of lemon juice, including fruit, cost of cask and labour.

The so-called extraordinary crops depend upon the mode of cultivation, and also climatic influences. Irrigation also enters largely in bringing it about. If a tree be deprived of irrigation during the hot months of July and August, and then abundantly watered in September, a spurt is put on producing an extraordinary amount of blossoms, which results in the valuable May crop. This cannot be done every year, for the tree suffers from the privation alluded to, and subsequent fruit is retarded in its development Yet, when the demand for May fruit is great, and prices range from 30*s.* to 40*s.* per 1,000, it is done, as these prices compensate for any loss in September and October.

The March crop, known as 'biancuzzi,' and which is the result of the August blossoming, is the least valuable, for it will not stand a long voyage. It is sent to Trieste in small cases. Neither does it yield essence nor juice. Prices average about 40 per cent. less than those obtained for good lemons.

The April yield from the September blossom is not much better than that of March, yet some good fruit may be picked out for packing, but nearly all is used for local purposes.

MAY CROP OR 'VERDELLI.'

The May yield, which is also the result of the September blossom, known as 'verdelli,' is much sought after, and is shipped to the States in small cases: the fruit is of excellent keeping quality, and easily stands the voyage. No care is necessary in gathering or sorting the fruit, as it is all good, worth 25 per cent. more than winter-grown fruit.

The so-called 'bastardi' are gathered in June and July, and are the result of October and November blossoming. They are packed in similar cases, and are sent to London, Liverpool, Trieste and the States.

In August and September the lemon crop is smaller than, and inferior to, those of the previous months. It realizes less on this account, and also because the lemon crop in south Spain begins.

PRODUCTION OF AN AVERAGE PLANTATION.

The following is a fair proportion of the divers kinds of lemons grown on a plantation of average size, which produces, we will say, 110,000 lemons annually:—

Month.	Number of Lemons gathered.
October	15,000
November	30,000
December	25,000
January	20,000
February	10,000
March	1,000
April-September	9,000

The last is only approximate, because it depends on whether the trees have been forced or not.

COST OF PACKING AND MAKING UP.

Cost of packing varies according to size of case:—

	Large.		Small.	
	s.	d.	s.	d.
Cost of case	0	9	0	6
" " paper	0	6	0	4
" " gathering and packing ..	0	4	0	3
Nails and hoops	0	1	0	1
	1	8	1	2

The management of a lemon plantation demands great attention. Trees should be trained high to admit free ventilation, pruning to take place regularly once a year. Dead wood, unhealthy and redundant branches removed. In cases of a heavy crop, the branches are to be supported. Trees to be watered in summer with a little liquid manure in the water once a week, and the ground kept free from all undergrowth. Market gardening is occasionally practised between the trees, because the vegetables grown pay expenses for manure and cultivation; but it is not to be recommended, as the fruit suffers in consequence.

The tree should always be grafted on the bitter orange; if grown from the pip, it is subject to a disease called the gum, which often destroys it. Grafting takes place after three years and is practised in the same way as on the rose tree.

SUITABLE LOCALITIES FOR CULTURE OF LEMONS.

Vice-consul Pignatorre also furnishes me with additional particulars on the subject. The tree requires an equal tempera-

ture. Lands bordering on the coast-line are the most favourable, provided the situation be a sheltered one, as the trees are very susceptible to great variation of temperature; yet they cannot be reared on a coast exposed to the strong south-west winds, nor in localities subject to frost. The north-east winds are the most injurious, from which they must be protected by intervening trees. Precautions to be taken against frost are indispensable. A keen wind will often blight a whole crop; in this case it is absolutely necessary to clip and clear away all branches that have been frost-bitten.

SEASON FOR PLANTING.

Under these conditions, more or less obtainable in Sicily, seed may be sown in the month of April, 2 or 3 centimeters [about $\frac{3}{4}$ to 1 inch,] beneath the surface: but the ground thus sown must be surrounded by a border of mould, and well watered. When the seedlings are large enough to be moved, they are transplanted into small holes prepared during the summer for that purpose.

The ground round lemon trees requires to be hoed three times a year—in December, after the heavy autumnal rains, in April, and lastly in May, in order that they may be easily watered in summer. To water a plantation of $2\frac{1}{2}$ acres twice a week, the quantity of water required is 10,500 hectolitres [37,075 cub. ft.] to continue from May to September.

The clearing away of dried twigs and suckers precedes the pruning, and sometimes renders the latter unnecessary. A proper pruning will often enable the trees to resist the effect of a violent sirocco.

The pickling of lemons for exportation is a very simple process. They are first cut in two and immersed in salt water from three to eight days; they are then placed in casks with alternate layers of salt. Salt water is then introduced to fill up spaces, and the cask is closed up ready for exportation.

MANUFACTURE OF ORANGE-FLOWER WATER A NEGLECTED INDUSTRY.

With all this, there is another industry in this connexion, which, it is to be regretted, is lost sight of in Sicily; or, if practised, it is only on a very small scale, i.e., that of collecting the petals of the blossoms, whether of orange or lemon, that fall off and cover the ground as soon as the fruit appears, for making orange-flower water, which I have seen practised in other orange-growing countries.

PICKLED LEMON AND ORANGE PEEL.

Mr. Consul Churchill also forwarded the following additional communications to His Majesty's Secretary of State for Foreign Affairs on the same subject. In Mr. Churchill's second despatch information is given relating to the trade in pickled lemon and orange peel;—

His Britannic Majesty's Consulate, Palermo,
January 26, 1903.

My Lord,

In reply to your Lordship's despatch No. 1, Commercial, of January 19, in regard to the condition of the Citrus Industry in Sicily, I have the honour most respectfully to submit that my last commercial report, that for 1901. contains on p. 8 a return of the exports of citrus fruits from Palermo during 1900 and 1901, on p. 17, a statement of the exports of essences and volatile oils, citrate of lime, dried orange peel, lemon juice, and oranges and lemons. On p. 13 there is a further mention of the discovery of a new parasite of the citrus as well as a note of the standard text-books on the diseases of the citrus.

Individual application has been made to me on behalf of other colonies for information on the same subject, and I have invariably used my best efforts to secure all possible details regarding the industry, even to making personal application to the Italian Minister for Commerce for the valuable text-books issued by his Excellency's Department on the citrus and its allied plants.

Under separate cover, I beg to lay before your Lordship (1) a report by Mr. W. Gatton A. Grasby (published in the *Garden and Field* of Adelaide: December 1898, July 1899) on Sicily and the Lemon Industry, (2 and 3) monograph on the citrus and its diseases, illustrated by Dr. O. Penriz, and (4) Report for 1902 of the Italian Ministry of Commerce and Agriculture on the citrus trade of Italy with foreign countries.

As it has already been possible for me to loan Mr. Grasby's report to many applicants for it, I should like to have it returned to me for further use.

I shall at once take action with a view to collect further material which may be of use to those of our colonies interested in the citrus industry.

I have, etc.,
(Sgd.) SIDNEY J. A. CHURCHILL.

His Britannic Majesty's Consulate,
Palermo,
March 6, 1903.

My Lord,

The trade in pickled (salted) lemon and orange peel is almost entirely confined to Messina, whence some 2,000 tons are exported annually principally to the United Kingdom, the United States, Germany and Austria.

The season is during January and February.

The fruit is cut in half and the pulp is extracted. The peel is then thrown into open casks of salt and water in proportion of 20 kilograms of rough salt to 100 kilograms of water. In this pickle 350 kilograms of peel is soaked for three or four days. The water is then drawn off and the peels are packed in layers in barrels to weigh 350 kilos., when ready for shipment. When the barrel is full, it is closed down and salt water is poured in

through the bung to fill up completely. When the fruit is saturated the cask is sealed.

The local price per barrel, subject to fluctuations as to the condition of the supply, is Lires 23 (17*s.* 7*d.*) at Messina, f.o.b., for pickled lemon peel, and Lires 31 (24*s.* 10*d.*) per barrel Messina f.o.b., for pickled bitter oranges.

Citrons sliced in half with their pulp are also exported.

The best kinds are the 'Diamante,' weighing from 1 ℔. to 2 ℔. each, price Lires 140 (£5 12*s.*) to Lires 160 (£6 8*s.*) per 350-℔. barrel, and the Calabrian Citron same weights: 1 ℔. to 2 ℔. each, Lires 102 (£4 1*s.* 8*d.*) to Lires 115 (£4 12*s.*) per barrel.

I have, etc.,

(Sgd.) SIDNEY J. A. CHURCHILL.

ESSENCE OF LEMON.

In the following despatch Mr. Churchill gives interesting information relating to the trade in essence of lemon:

His Britannic Majesty's Consulate for Sicily,
Palermo,
March 5, 1903.

My Lord,

In continuation of my despatch No. 4 in this series on the Citrus Industry of Sicily, I have the honour to submit, herewith, samples of the essence of lemon produced at Palermo. This essence is difficult to procure in a pure and trustworthy form. It will not keep good except in well-soldered and tinned coppers. The small 1-℔. coppers usually in demand for confectioners are made in two parts only. They are to be obtained only at Messina. The sample sent, herewith, is of Palermitan manufacture and is in three pieces soldered together. The essence sold here is purchased under guarantee subject to the analysis of one of the British analytical chemists established in Sicily, who extract a sample and seal the copper exported.

To-day's quotation for the essence sent—that of Messrs. Jung Brothers, of Palermo,—is 2*s.* 5*d.* per ℔., f.o.b. at Palermo, including 5 per cent. commission, subject to 1 per cent. discount and including coppers from 10 ℔. to 100 ℔. Disputes as to contents to be subject to Messrs. Ogden and Moore's analysis.

This essence is made of inferior and refuse lemons unfit for export in any other shape.

The sample boxes are made at Bari, in Italy; the thin colourless glass bottles are called English glass bottles: the corks are cut from Sicilian bark.

Any other detail of this industry which may interest British colonies producing the citrus will be gladly reported on.

I have, etc.,

(Sgd.) SIDNEY J. A. CHURCHILL.

The following supplementary information on this subject, embodied in a report on 'The trade in citrus fruits in Sicily, and especially in the province of Messina,' which originally appeared in the *Bulletin de l'office*, is taken from the *Agricultural Gazette of New South Wales* for December 1903:—

In Sicily the very greatest care is taken in the operations which precede the shipments of citrus fruits to foreign countries. At the time of gathering a preliminary sorting takes place either in the open air or in the stores on the plantations. The fruit is divided into three classes—(1) largest, healthiest and finest in appearance; (2) sound fruit of good quality, but of smaller size and less regular in shape; (3) deformed, withered, or spotted fruit, or fruit liable to early decomposition. The average of 1,000 generally comes out about 300 to 500 of the first quality; 200 to 300 of the second, and 200 to 300 of the inferior quality and waste: but these proportions may vary considerably according to locality, treatment of the trees, and the atmospheric influences of the year. The proprietors generally sell their crops by contract, before they are gathered, to speculators, but have to fix a certain latest date for delivery. These sales are effected through intermediate brokers called 'country brokers.'

Immediately on conclusion of the contract, the buyer pays a portion of the value in advance, and the balance in two or three instalments, but always before the fruit is all gathered. The buyers run all the risks of loss by diseases, intemperate weather, or falling prices. They also do the first grading on the spot; pack the fruit in cases and despatch these to stores in the ports, where the town brokers have charge of the sales to the export houses, which all belong to natives. These sales are made either for cash or at thirty days, if to a firm of good standing. The cases are opened in the warehouses of the export firms and again examined, when generally from 10 to 20 per cent. are rejected. Each fruit is wrapped in white or coloured tissue paper and put back into the cases. Sometimes, but very seldom, the owners ship direct through the town brokers.

The cases are usually twice as long as the width, and the depth is a shade less than the width. At Messina the lemons are packed in three different sizes of cases; the large ones, called 'Uso Toudres,' are sent principally to England. They measure 32 inches in length and 12 inches in depth, weigh 150 ℔. to 170 ℔. and contain from 300 to 360 lemons. The medium-sized cases are sent to America and Hungary, and measure 28 inches in length by 11 inches in depth, weigh 90 to 95 ℔., and contain from 300 to 360 smaller lemons. The smallest cases called 'Lyonnaises,' are shipped exclusively to France. These contain from 400 to 420 of the smallest lemons, have a length of 31 inches by 10½ inches depth, and weigh 112 to 133 ℔. The oranges are packed in large and half cases, the first containing from 200 to 240, and weighing about 80 ℔. The half cases contain 100 oranges, all of the same shape, size and colour, and weigh about 45 ℔. The mandarins are packed in cases containing 100 and 200, and some choice ones fifty. The

wood used for the cases is Austrian or Calabrian beech, and they are strengthened with hoops of chestnut and divided in the middle by a partition. The ends and the partitions are much stronger than the other parts. The inside is lined with white or coloured paper, which is folded over the top layer before the case is nailed up. Between each layer are placed slips of paper, or, still better, cork shavings to absorb the moisture. The cost of cases and packing comes to about 3*s.* per cwt.

The shipments of 'Verdelli' lemons to distant parts, such as Australia, are the subject of very special care. The finest fruit is chosen and packed in a green state. These lemons must have no defect whatever, nor even indications of any spots, in fact they must be perfect. They ripen during the voyage, which generally lasts about seven weeks. The sorting is done by special experts, three of whom generally examine the fruit successively. This operation is considered essential and requires great experience: in fact, only a very practised eye can distinguish the almost imperceptible specks which may contain the germs of future spots. Notwithstanding these precautions, only about two out of five shipments arrive in a good condition. At the port of discharge the cases are examined by the Australian authorities, and the bad or spotted fruit is thrown into the sea. Bad ventilation in the steamer holds is supposed to be the principal cause of the deterioration.

There exist no special types with ready sale, except the 'Verdelli,' which are in great demand on account of their good keeping qualities. The first and second qualities are shipped elsewhere, but Russia only buys the choicest products. Blood oranges, which are a special product of the province Catania, find a ready sale in Russia, Austro-Hungary and Germany. They are packed in cases containing 180 to 200 each, and are not mixed with other varieties of oranges.

The third quality of fruit is sold on the spot for making cordials and essences. The shipments are generally made in winter, either to order, or, more frequently, on consignment. In the former case, the exporter generally demands advance payment, and draws at sixty days. In the latter case, the local agents of the importing houses are authorized to make partial advances of from half to two-thirds of the value of the shipment. Public auction sales of citrus fruits have been established some years in the principal markets, such as Hamburg, Buda-Pesth, London, Trieste, Berlin, New York, etc. Official lists of the prices obtained are regularly published. This mode of sale has given good results, and the Italian Chamber of Commerce in Paris strongly recommends it in order to encourage the importation of Sicilian citrus fruits in France.

In order to save the cost of transport, the public auction sales are generally held in the stores where the fruit is deposited. The prices of citrus fruit for export have lately fallen considerably; for instance, 'Paterno' oranges, quoted some years ago at 24*s.* per 1,000, are now obtainable at 16*s.* to 14*s.* Francofonte and neighbouring districts quote 8*s.* to 15*s.*

per 1,000. Blood oranges are worth about 33 per cent. more than 'Paterno,' and even double, if the flesh has preserved its red, vinous colour at the beginning of January.

The winter lemons are sold at 2*s.* 4*d.* to 6*s.* per 1,000 (say about 270 lb. weight): the summer ones ('Verdelli') at 14*s.* to 24*s.* per 1,000, and the mandarins at 2*s.* to 3*s.* per case of 100. It is impossible to give the sale prices abroad, as they vary considerably in the different markets.

The following table shows the approximate freight and duration of the voyage from Messina to the principal ports:—

	Days.	Freight.
Hamburg (by sailing vessel) ...	20 to 25	1*s.* per case.
London (sailing vessel) ...	20 to 25	1*s.* large, 8*d.* small case.
Trieste	3 to 4	4*d.* to 5*d.* large case.
Odessa	8 to 10	7*d.* to 7½*d.* large case.
New York	8 to 10	10*d.* to 1*s.* large case.

The total export of lemons and oranges in cases from Messina in 1901 amounted to 93,450 tons, valued at £375,000, distributed as follows:—

	Tons.		Tons.
United States	19,200	Australia	4,100
Austro-Hungary ...	17,900	Sweden and Norway ...	2,600
Russia	14,500	France	2,200
Germany	12,300	Holland	2,000
England	9,800	Other parts	4,070
Canada	4,700		

The table below gives the total export from the whole of Italy, with average values:—

Period.	Average.			
	Annual Quantity in cwt.	Price per cwt.		Annual Value.
		s.	*d.*	£
1862–1865	1,340,000	16	0	1,072,000
1866–1870	1,578,000	16	0	1,262,400
1871–1875	1,712,000	11	6	984,000
1876–1880	1,898,000	11	0	1,043,900
1881–1885	2,845,000	8	6	1,209,250
1885–1890	3,776,000	7	0	1,321,600
1891–1895	3,743,000	6	0	1,122,900
1896–1898	4,381,000	5	3	1,149,500

Showing a constantly increasing quantity, but a decline in prices. In addition to the above, a large export takes place in essences, concentrated lemon juice, peels, and trees. The Italian oranges are exported to twenty-one different countries, and the lemons to twenty-three. They are admitted free in England and Austria, but pay a duty per cwt. of about 2*s.* in Germany, 7*s.* 6*d.* in Russia, 2*s.* in France, 10*d.* in Switzerland, and 4*s.* 6*d.* in the United States.

Notwithstanding numerous variations, the United States is still the best customer, and takes 43 per cent. of the total export; next comes England with 21 per cent., and Austria 16 per cent. The export to Australia was nil in 1887, but has now reached important dimensions. Italy cultivates about 113,000 acres, producing 4,500,000 of citrus fruits, of which 2,000,000 are exported.

THE BIRDS OF ST. VINCENT.

INTRODUCTION.

In continuation of the articles that have appeared in the *West Indian Bulletin* on the birds of Barbados (Vol. III, pp. 333-35, and Vol. IV, pp. 136-44) it is now proposed to publish information in respect of the interesting bird-life of St. Vincent.

It is desirable, however, to give, beforehand, a brief description of the island, the extent of the forest land, its configuration, soil and climate.

The following account of St. Vincent is taken from the *Kew Bulletin* (1893. pp. 231-34):—

St. Vincent is one of the group of islands known in the West Indies as the Colony of the Windward Islands. The other members of this group are St. Lucia, 21 miles to the north, and Grenada, 68 miles to the south-west. Barbados, under a separate Government, is 100 miles due east.

St. Vincent was discovered by Columbus on January 22. 1498. It is situated in 13° 10′ north latitude and 60° 57′ west longitude. It is 18 miles in length and 11 in breadth, and contains, according to the *Colonial Office List*, nearly 85,000 acres of land, about half the area of Middlesex, with only 13,000 acres under permanent cultivation. The population in 1891 was 41,054. The majority of the adjoining islets, known as the Grenadines, are dependencies of St. Vincent. The following account of these is taken from the excellent 'Historical Geography of the Colonies,' by Mr. C. P. Lucas, C.B., of the Colonial Office:—'These dependencies contained at the last census a population of 2,691, the largest of them being Bequia, the next largest Union Island and Cannouan. Bequia is less than 9 miles to the south of St. Vincent. It is of irregular shape, long and narrow, running from north-east to south-west, and it has an area of about 6 square miles. Its principal bay is Admiralty Bay on the western side. It is badly watered, and perhaps hardly deserves the old account given of it in the history of the Caribby Islands, that "it would be fruitful enough, if it were cultivated," for but little

sugar or other products are now grown here, and the main attraction of the island is its game. Père Labat states that in his time Bequia contained dangerous snakes, and was for that reason called Little Martinique, though, as he says, it might equally well for the same reason have been christened Little St. Lucia.' (pp. 220-1.)

According to Bryan Edwards (*Hist. West Indies*, I., p. 405), the area of the several islands in the Grenadines is as follows:—Bequia, 3,700 acres; Union, 2,150 acres; Cannouan, 1,777 acres; and Mustique, about 1,200 acres.

The following particulars of the physical condition of St. Vincent are taken from a *Sketch of the Colony* prepared by Mr. T. B. C. Musgrave for the Jamaica Exhibition, 1891:—

'The geological formation of St. Vincent is volcanic, all the rocks of the island indicating that origin. So recently as in 1812 the "Soufrière," a mountain at the north end of the island, 4,048 feet high, broke out in eruption and overwhelmed much of the surrounding country with scoria and ashes; a deep crater was then formed, closely adjoining one of still larger dimensions, the result of an eruption at a period more remote. At the bottom of the older crater, some 1,600 feet down, is a small lake about a mile in diameter. The water appears impregnated with sulphur and occasionally emits offensive though invisible fumes.

'A central backbone of mountainous country varying in height from 2,000 to 4,000 feet, and densely wooded, traverses St. Vincent from north to south. Rocky and wooded spurs run down to the sea on the west or leeward coast of the island. The east or windward coast, especially towards the north end of the island, in the Carib country, affords much more level land.

'The Carib country is a broad and fertile tract sloping gently backwards from the sea, for a distance of some 4 miles, to the base of the hills of the central mountain range which then rises abruptly and culminates in the Soufrière. It derives its name from having, upwards of a century ago, been allotted to the aborigines of the island for their occupation.

'The Soufrière forms the northern end of this mountain range. Next to it is the Morne Agarou, having an elevation of over 4,000 feet. Mount St. Andrew, about 2,500 feet, forms the southern extremity, and dominates the Kingstown valley.

'The valleys are fertile and well watered, with fine streams running through them, which turn the different water mills. These streams, in the dry season, comparatively small, swell into raging torrents after heavy rains. The windward slopes of the Soufrière range are drained by a channel called the Dry River, which runs through the Carib country, and which from its peculiarity deserves notice.

'Before the eruption of the Soufrière in 1812, a stream of average size filled this, now dry, watercourse, and emptied itself into the sea. During the eruption, the channel of the stream was completely filled and choked with scoria, rocks, and gravel, underneath which the water now, in ordinary times,

disappears some distance before it reaches the coast, and finds its way to the sea. In floods, however, the water comes down with singular force and volume, filling the rocky bed, which is 200 yards across, where the highway passes it from bank to bank. The water is described as advancing in huge waves, like the "bore" of a tideway. On these occasions it is very destructive, and it has already washed away many acres of cane land on its right bank.'

The slopes of the higher mountains are scored with deep ravines, and during the rainy season white clouds hover over them day and night. Here the vegetation partakes largely of an arboreal character, with an abundant undergrowth of ferns, and on the margins and banks of streams, species of *Scitamineae*, *Aroideae*, *Cyperaceae*, and some palms. Of tree ferns there are four species of *Cyathea*, two species of *Hemitelia*, and three species of *Alsophila*. At all elevations on mountain slopes are numerous open glades, showing the sites of former cultivation—the provision grounds of the natives—that have become covered with coarse grasses and dry-loving ferns. The characteristic fern of such localities is *Gleichenia*.

In the lowlands, in valleys and on easy slopes, the original vegetation has been for the most part cleared for the cultivation of sugar-cane, arrowroot and other plants. On rocky cliffs are found numerous bushes and trees of stunted growth, some of them overhanging the sea. With these are an *Agave* and *Bromeliaceae*.

St. Vincent is singularly free from swamps. Hence, there is nowhere any large extent of the tangled vegetation so characteristic of swampy districts in the tropics. The mangrove trees are only sparingly distributed. The manchineel tree (*Hippomane Mancinella*) and the sea-side grape (*Coccoloba uvifera*) are found on sea beaches.

'The climate is, of course, tropical. The temperature is singularly equable and averages between 75° and 85° degrees. It is tempered by the N. E. trade winds during nine months of the year. During the months of August, September and October, the winds become variable, and not infrequently veer to the south or south-west. Hurricanes or heavy gales are rare. St. Vincent is one of the most healthy islands of the West Indies. The slope of the land causes a natural drainage, and there are no swamps or marshes.'

In 1890, the Assistant Director of the Royal Gardens [now Imperial Commissioner of Agriculture for the West Indies] visited St. Vincent during a term of inspection throughout the West Indies, made at the instance of the Secretary of State. His report, which embodies many particulars regarding its present economic position, will be found in the *Kew Bulletin* for 1890 (pp. 140-5).

In the last century St. Vincent was remarkable for possessing the first Botanic Garden (founded 1765), certainly in the West Indies, and perhaps in any tropical part of the world. An account of this garden is given in the *Kew Bulletin* for

1892, (pp. 92-100). It lingered on with a precarious existence till the end of the first quarter of the present century. In 1890, it was revived as one of the system of botanical stations established in the West Indies.

The scientific knowledge of the flora of St. Vincent was limited to the present time to the species enumerated in Grisebach's 'Flora of the British West India Islands' (1864). He relied upon a collection made by the Rev. Lansdown Guilding, preserved in the Kew Herbarium. As will be seen, the fact that these specimens were in every case actually derived from the island is not free from doubt. Besides these Grisebach also worked up some other plants in the Kew Herbarium collected by Alexander Anderson, the second Superintendent of the old Botanic Garden, of whom some particulars are given in the *Kew Bulletin* for 1892 (pp. 94-5), also by George Caley, one of Anderson's successors (*Kew Bulletin*, l.c., p. 97).

These data supplied at first a very imperfect idea of the total flora. It was obviously, therefore, desirable to take advantage of any opportunity for completing the botanical exploration of the island. In 1889, Mr. F. Ducane Godman, F.R.S., to whom the scientific world is indebted for the munificent investigation of the natural history of Central America, determined to send a zoological collector to St. Vincent. Mr. H. H. Smith, a native of the United States, and an expert of known skill and experience, was engaged. He was accompanied by his wife, and Mr. Godman, thinking that they might also do some useful work for botany, persuaded them after a visit to Kew to undertake the task. On arriving at St. Vincent they ultimately engaged as assistant in botanical collecting Mr. G. W. Smith (now Police Magistrate for the Northern District of Grenada).

The very copious collections made by the party during the years 1889 and 1890, at Mr. Godman's cost, were presented by him to the Royal Gardens. There is every reason to suppose that as far as it is practicable under such circumstances, they exhaust the actual flora so far as flowering plants and ferns are concerned. But there will be, doubtless, as even in our own country, always some additional harvest of species to be obtained by residents in the island, who can give their time to a closer investigation of its area. Mr. H. Powell, the Curator of the revived Botanic Garden, has done good service by sending additional collections since 1890.

As regards the arboreal vegetation of St. Vincent and the most prominent and valuable timber trees of the island, the most recent particulars are given in a *Report upon the Forests of St. Vincent* by E. D. M. Hooper, of the Indian Forest Department, published by the Colonial Office in 1886.

A report upon the fruits of the colony will be found in the *Kew Bulletin* for 1888 (pp. 187-8).

The position of the once flourishing but now somewhat decaying arrowroot industry is discussed in the *Kew Bulletin* for 1893 (pp. 191-204).

In recent years St. Vincent has been subject to several visitations that have affected the growth of vegetation and no doubt, also, seriously influenced the bird-life of the island.

On September 11, 1898, St. Vincent was overtaken by one of the most destructive hurricanes that has ever occurred in the West Indies. The centre of the storm passed over the island and almost entirely destroyed all the interior forests, as well as the fruit trees and crops on the cultivated lands round the coast. The number of birds was sensibly diminished, and it was feared that some of the rarer birds had either been killed or starved for want of food.

On May 7, 1902, occurred the first of the series of eruptions of the St. Vincent Soufrière. On this occasion the animal and vegetable life in the immediate neighbourhood of the Soufrière was destroyed and the pebbles and dust that fell in other parts of the island also caused much injury. Further volcanic eruptions, but of a less severe character, occurred on September 3 to 4, and October 15 to 16, 1902; and March 22, 1903.

As far as can be ascertained, no birds—not even the well-known Soufrière bird—have entirely disappeared. It is probable that with the favourable seasons of this and last year bird-life in St. Vincent, as well as at Barbados and elsewhere, will assume normal proportions.

The following is a list of the birds which occur in the colony of St. Vincent, that is, the species inhabiting the island of St. Vincent and the Grenadines as far as, but not including, Carriacou, prepared by Mr. Austin H. Clarke, of Harvard University, who has lately spent some time in these islands:—

NAMES.

The scientific names of the birds are given together with their local designations. In the case of such species as appear to be without any common name, I have given that in common use at Grenada; or, if the bird does not occur on that island, I have adopted an arbitrary name to fit the case. Some of the local names are commonly used to include two or more different species. For instance, the word 'grieve' is applied to *Merula nigrirostris*, *Merula gymnophthalma*, and *Margarops montanus*; 'blackbird' is used for both *Certhiola atrata* and *Quiscalus luminosus*. In such cases I have selected one bird to be referred to under that title, and have called the others by alternative names, if there are such in common use, or have borrowed the local Grenada titles. In the case of such birds as visit the colony from North America, I have given the names which they bear in the United States and Canada as determined by the American Ornithologists' Union. These names have now become definitely fixed in America, and the birds are always referred to under them in all modern ornithological notes in that country. This refers particularly to the shore birds (curlews, plovers, sandpipers, etc.). Where (as in the case of the chicken hawk or sea hawk) a bird is common enough here to have received a distinctive local designation, that is given first and the American name after it.

NAMES OF SHORE BIRDS.

With the shore birds I have followed the American name with that in use in Barbados, as given by Col. Feilden in his 'Birds of Barbados' (*West Indian Bulletin*, Vol. III, p. 333), for the benefit of those who may be acquainted with the species in Barbados.

FOREIGN BIRDS INCLUDED IN THE LIST.

The list includes, in addition to the birds known to inhabit the colony, certain species, especially among the shore birds, which have never been obtained here, but which have been proved to occur on neighbouring islands, (Grenada, certain Grenadines, St. Lucia, or Barbados) and which may visit the island at any time. These are such species as pass through the West Indies on their way to and from North America, and are of erratic and uncertain occurrence on any one island.

LOCAL DISTRIBUTION.

Certain of the birds inhabit only the Island of St. Vincent while some are found only on certain of the Keys. For example, *Myiadestes sibilans* does not occur in the smaller islands, while *Ortalida ruficauda*, the *cocorico*, is restricted, as regards this colony, to two of the Grenadines. I have omitted to state the local distribution of the different species, as by so doing I should be depriving those who wish to make a study of the birds here, of the chance of making most interesting personal observations.

THE LIST NOT A CRITICAL SCIENTIFIC ENUMERATION.

This list is intended as a guide to the study of the natural birds in this colony, and as an aid in protective legislation. It is not, in any sense, a scientific enumeration of the birds of St. Vincent, including, as explained, a number of species which have never been taken here. It cannot therefore be regarded in the same light as Mr. Well's 'Birds of Grenada,' or 'Birds of Carriacou,' or Col. Feilden's 'Birds of Barbados.' The preparation of a critical paper on the avifauna of any country, district or island necessitates ready-access to a well-stocked ornithological library, which is impossible for any person residing in the Windward Islands; but for the use for which it is intended this list will, I hope, be found to serve its purpose.

DESCRIPTIONS GIVEN.

In the case of the land birds, the length from the tip of the bill to the end of the tail is given, to facilitate identification. For instance, there are three birds here, *Certhiola atrata*, the St. Vincent Blackbird, *Quiscalus luminosus*, the Bequia Sweet, and *Crotophaga ani*, the Tick bird, which are all black in colour; but confusion is avoided when their relative sizes, 4 inches, 10½ inches and 12¼ inches, are understood.

Length: The length is that of a bird perched normally on a limb, with its head not extended. A little practice will enable one to judge pretty accurately the size of a bird at sight. In the case of the sea birds, which are difficult to judge

in this way. I have adopted a plan of comparative sizes, which, when taken in connexion with the colours, will, I think, be found sufficient for their determination.

Colour : In the matter of coloration I have not gone into detail, but the descriptions given will be found to be ample.

GAME BIRDS.

ENUMERATION.

The birds of this colony which may be classed as game birds are—(1) the visiting shore birds (curlews, plovers, etc.) which pass through here on their migrations; (2) the larger native doves; (3) the parrot; (4) the cocorico; and (5) the quail.

THE SHORE BIRDS.

None of these birds are natives of the Windward Islands, most of them breeding in the far north. Those found on these shores during migrations are so small a percentage of the whole, and their stay is, as a rule, so short, that there seems to me to be no occasion for according them any protection at all.

Cause of decrease : Some species are, it is true, being seriously reduced in numbers; but this is without doubt due to the reckless shooting of the birds in the spring on or near their breeding grounds in the north. There is little reason to think that the comparatively insignificant number killed here each year could have any permanent effect on the species. In respect to these birds, therefore, there is no cause to alter the present law.

DOVES.

The larger native doves : This is meant to include the Sea-side Dove (*Zenaida martinicana*), the Mountain Dove (*Zenaida zenaida*) and the Ramier (*Columba corensis*). From what I have seen I am of the opinion that the existing law is very satisfactory, as these birds are relatively abundant.

THE PARROT.

Notwithstanding reports to the contrary, this bird is not at all abundant, being at the present time restricted to a comparatively small area in the centre of the island: and even there, it is not to be found in any numbers. In dealing with a bird of this kind it must be borne in mind that they are very restless, very noisy, and of such a size as to be quickly noticed: so that, if there be a parrot in the vicinity, one will soon become acquainted with the fact. As it will probably keep flying about, back and forth, one may easily fall into the error of supposing that there is a considerable number of parrots about; but if one can distinguish that particular one in any way, by a gap in one or both wings, or in the tail, one will, on watching closely, soon discover the mistake. This fact I have proved myself.

Importance of this species : As this particular species is peculiar to the island of St. Vincent, being wholly different from all others occurring in the West Indies, its extermination would

mean not only the loss of a valuable game bird to St. Vincent, but it would deprive the West Indies of one of their greatest ornithological curiosities, and America of one of its finest birds.

Reasons why parrots are easily killed out: There are two facts which make parrots easy to kill out: first, they feed at different seasons on particular fruits, and can then be obtained with little difficulty by simply stationing oneself within gun-shot of a favourite feeding-tree: in the second place, they are very sympathetic birds, and if one in a flock be wounded, often the others will stay by it until they are all killed. I have seen the disastrous results of this habit in South America.

Extinct Parrots: To show that parrots are very liable to become extinct, particularly species confined to islands, I will call to mind a few cases. In the West Indies, Martinique and Guadaloupe used to have, according to M. Guyon, six species, none of which are now known. Jamaica until fairly recent years had a very fine macaw. The handsome Cuban macaw (*Ara tricolor*) is practically extinct, though by some said still to linger in certain of the swamps of Cuba. In the East Indies, the Philip Island parrot (*Nestor productus*) and its near ally the Norfolk Island parrot (*Nestor norfolcensis*) have disappeared, together with a parrakeet (*Palæornis exsul*) from Rodriguez. In North America, the Carolina parrakeet (*Conurus cariolinensis*) originally occurred from Indiana southward to the Gulf of Mexico. It is now confined to a few swamps on the gulf coast, where it is not at all common.

Conclusion: I think the foregoing shows the advisability of affording strict protection to the St. Vincent parrot until such time as he can be considered at least fairly abundant.

Penalty for killing parrots: In regard to the penalty attached to the infringement of the game laws, this should be made especially heavy in regard to the parrot, or the case might arise (analogous to what has happened in other places) in which a dead parrot might bring enough to cover the fine and yet yield a profit. The present law of Bermuda provides a penalty of £10 for killing a Long-tail or Tropic Bird (*Phaethon flavirostris*), practically the only sea bird now breeding in Bermuda. The result is, of course, perfect immunity, and the species is abundant. It seems to me that some such fine should be imposed for the illegal killing of this parrot, which is a more interesting, as well as much more beautiful, bird than this common and widely distributed sea-fowl.*

COCORICO.

This bird appears to be well established, and is in no danger of extermination in the islands on which it occurs. As

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* According to Mr. Henry Powell (February 22, 1904), 'At the Zoological Gardens, London, there is a solitary St. Vincent parrot, and that was presented by the Earl of Balcarres who obtained it direct from St. Vincent. No specimen of this parrot exists at the Cromwell Road Museum, nor at Marseilles, where the collection of birds in general and the method of mounting them are considered especially good.'

We understand that recently five specimens of this rare parrot were killed for a collector! [Ed. *W.I.B.*].

it is not a native, and is abundant in Tobago and on the continent, if it should be accidentally killed out, a new lot could be readily imported. There seems to be no necessity for legislation of any kind as far as this bird is concerned.

QUAIL.

Like the preceding, this is not a West Indian bird. It would be best, I think, to leave its fate in the hands of those upon whose estates it occurs, as, if it were killed out, it could be easily re-introduced.

PROTECTION OF SEA BIRDS.

Danger of killing on breeding grounds: In regard to the sea birds of this colony, they are not the subject of appreciable persecution at any time, and they are fairly abundant. So long as their breeding grounds are undisturbed, the few usually killed away from them should make no difference in their economy. Wholesale destruction of their eggs and young, however, would soon either kill out the birds, or drive them away. I will cite a few cases in support of this.

Locally extinct species: In the early days of Bermuda, the people were more or less dependant on a certain sea-fowl known to them as the 'cabouse.' This bird was closely related to, if not identical with, the Diablotin (*Puffinus auduboni*). It was killed by hundreds on the islands on which it bred, with the result that it soon disappeared. Another West Indian bird, closely related to the 'cabouse,' has been killed out of several of the islands. I refer, of course, to the Burrowing Petrel (*Aestrelata hasitata*) known in some of the islands as the 'diablotin.' Owing to constant persecution, the sea birds breeding on the coast of New England became alarmingly reduced in numbers, some species, in fact, almost, if not quite, disappearing. Of late years, however, they have been strictly protected, a warden being stationed in the more important colonies, with the result that they are now showing a definite increase. I give these instances, not because of any immediate danger to the sea-fowl here, but simply to show what might happen if, when serious reduction in numbers were imminent, the matter were not at once taken up.

THE CHICKEN HAWK.

The common Chicken Hawk (*Buteo latissimus*) proves, on investigation, to be, perhaps, as much of a benefit to the agriculturist as it is a pest to the poultry raiser, since it subsists very largely on the mole cricket, sometimes as many as twenty or more being disposed of at one meal. It is not at all rare to find an insectivorous diet among the smaller hawks; as examples, I may mention the Florida representative of the West Indian Kili-hawk (*Falco caribbaearum*), which is known to exist mainly on grass-hoppers, and the Margarita Kili-kili which, according to Captain Robinson, lives upon the same pests. It appears, therefore, that if it be considered unwise to protect this bird, at least no bounties or rewards should be offered to aid in its destruction.

PROTECTION OF THE SMALL BIRDS.

The spirit of the existing law affords suitable protection for the small birds. In a law relating to birds of this class I am of the opinion that it is wise to make as few exceptions as possible, and if any be made, that they be of really injurious and manifestly undesirable species, and such as are well known to everyone, so that there can be no confusion ; otherwise it will defeat the aim of the law in regard to species having a more or less close resemblance to those left unprotected. This is the case to-day in many of the American States, where certain definite birds (such as the English sparrow) are unprotected, and advantage is taken by small boys with air guns to kill any of a dozen or so species of the smaller and duller birds, which will pass as sparrows if they happen to encounter a police constable of average intellect in their wanderings. Thus in St. Vincent if the Grass bird were unprotected, the Blue Head (*Euphonia flavifrons*), Hen Red Breast (*Loxigilla noctis*) and Lady bird (*Vireo calidris*) might suffer ; if the Bequia Sweet (*Quiscalus luminosus*), it might be injurious to the Tick bird (*Crotophaga ani*), etc.

BOOKS ON LOCAL ORNITHOLOGY.

I have appended a list of such books and articles as would be of value to anyone interested in native birds. The list includes references to the literature on the birds of the Windward Islands, and is not confined exclusively to that of St. Vincent. The most useful books are perhaps Cory's 'Birds of the West Indies', and Ridgeway's 'Birds of North and Middle America'. The former, while giving minute descriptions of the native birds, only mentions by the scientific name such North American species as regularly or occasionally visit this island. Thus, for these it would have to be used in connexion with some standard American work, such as Chapman's 'Birds of Eastern North America.' There are no local names given for the West Indian birds, but this will not be found to present any difficulty, if it be used in connexion with this list. Ridgeway's book contains detailed and minute accounts of all the birds occurring in the West Indies, and is a most valuable book of reference, in fact, the best on the subject up to date.

The works mentioned may be obtained through the larger dealers in scientific books, such as Dulau & Co., London ; List and Franke, Berlin, or Oswald Wiegel, Leipzig, who often have them on hand, either as separates, or in part of the volumes in which they occur. As practically all are out of print, there is no other way of getting hold of them.

INTRODUCTION OF FOREIGN BIRDS.

One point I should like to bring up. It has been proved to be bad policy to introduce foreign birds or mammals into a country, except in the case of such as can be readily killed out if occasion requires it: that is, large herbivorous mammals, or game birds. Introduced species are liable to take on certain habits which render them obnoxious, however beneficial they may have been in their own country, and which it may be wholly impossible to foretell. To show to what an extent

change of habit may go, I will mention the case of the New Zealand Kea, a large parrot, which originally fed on vegetable products. Some time after the importation of sheep into the country, the Kea developed a propensity for eating their kidneys, and has proved to be a serious pest in consequence. This habit must be wholly of recent origin, for before the discovery of the island, New Zealand possessed no native mammals whatever. This is, of course, an extreme case, and I only cite it to show how sometimes a bird's habit will wholly change under new conditions.

In their own country, the animals and birds are kept in check by their natural enemies, parasites and diseases. If, then, we bring them into a new place, we are liable to find out that the results are not what was expected, while at the same time they may increase beyond our control. Of course, on the other hand, many, if not most, introduced species die out, being unable to meet the new conditions of life forced upon them.

As a few tangible bits of evidence are worth more than whole pages of theory, I will give a few cases in support of the foregoing.

The European House Sparrow (*Passer domesticus*) has been introduced into North America, Australia, New Zealand, Argentina, Mauritius, Comoro Islands, New Caledonia, Hawaii, Chatham Island, (*Ibis*, 1893), Bermuda, the Bahamas and Cuba, in practically all of which places it takes its place among the pests. In fact, it is by some considered in New Zealand to be second only to the rabbit. (*Report, New Zealand Department of Agriculture*, 1897.)

The Starling (*Sturnus vulgaris*) would appear to be rather an aid to agriculture than otherwise; for Mr. John Gilmorn has shown (*Trans. Highland and Agricultural Society*, Scotland, 1896) that its food consists in England of 75 per cent. insects, 20 per cent. grain (mainly waste), and 5 per cent. miscellaneous food. After its introduction into New Zealand, however, it adopted largely a fruit diet, and has therefore become a great nuisance. (*Producers' Gazette*, Western Australia, January 1898.) In Tasmania also it feeds largely on small fruit, cherries, and wheat. (*Agricultural Gazette*, Tasmania, November 1897, and January 1898.)

The Nima (*Acridotheres tristis*), an Indian bird, something like the Bequia Sweet (*Quiscalus luminosus*), has been introduced into Mauritius (Jerden, 'Birds of India,' 1863), Andamans, Hawaii, New Zealand, and Australia. It is proved (Finsch, *Ibis*, 1880) to drive away pigeons and fowls, and is said to destroy their eggs and nests.

I may also mention the case of the Skylark (*Alauda arvensis*), the Green Linnet (*Ligurinus chloris*), and the Blackbird (*Turdus merula*), which, although universally considered beneficial in England, have proved quite the reverse in New Zealand.

I think the foregoing tends to show the advisability of etting the native faunas of these islands alone; for no one can properly judge of the effects of a new bird or mammal on

them, or on the agricultural industry, until it is introduced, and then it is too late.

It seems, then, that it would be well to introduce into the Game Laws a clause prohibiting the importation of exotic birds or mammals, or at least requiring written statements from some acknowledged authority on the subject that they could not become obnoxious. Western Australia (*Jour. Bureau Agricultural*, December 10, 1895) and the United States have already taken the initiative in laws of this kind, while Cape Colony has gone as far as to exclude rabbits, and require that those kept in captivity be closely guarded.

LIST OF THE BIRDS OF ST. VINCENT.

1. MERULA GYMNOPTHALMA. Yam Bird. Yellow-eyed Grieve.

$8\frac{1}{2}$ inches. Dull olive brown, lighter below: naked skin, about eye yellow.

2. MERULA NIGRIROSTRIS. Grieve.

9 inches. Brown, lighter below.

3. MYIADESTES SIBILANS. Soufrière Bird.

$7\frac{1}{4}$ inches. Nearly black: underparts gray, throat and belly orange rufous. White markings on inner nibs of tail and wing feathers.

4. MARGAROPS MONTANUS. Spotted Grieve.

$9\frac{1}{4}$ inches. Brown, belly white. Dull white markings on wings, tail feathers tipped with white, and white edgings to breast feathers.

5. MIMUS GILVUS. Mocking Bird.

$8\frac{3}{4}$ inches. Gray, white below. Tips of tail feathers and markings on wings, white.

6. THRYOTHORUS MUSICUS. Wall Bird. Wren.

5 inches. Rusty brown, narrow black lines across wing and tail feathers. White below.

7. CARTHAROPEGA BISHOPI. Lesser Soufrière Bird.

$5\frac{1}{4}$ inches. Back and band across breast, black. Circle about eye, throat, and belly, white.

8. SEIURUS AUROCAPILLUS. Oven Bird (U.S.).

$5\frac{1}{2}$ inches. Olive green, lighter below. Centre of crown, dull orange, with a black line on each side.

9. SEIURUS NAEVIUS. Water Thrush (U.S.).

5 inches. Brown above, underparts and line over eye, white.

10. CERTHIOLA SACCHARINA. Mistletoe-bird.

4 inches. Dark-slaty above, underparts and lower back bright yellow; white line over eye, and white patch on wing.

11. CERTHIOLA ATRATA. St. Vincent Blackbird.

4 inches. Black.

12. PROGNE DOMINICENSIS. West Indian Martin.

7 inches. Steel blue; middle of breast and belly, white.

13. PETROCHELIDON FULVA. Eave Swallow.

$4\frac{3}{4}$ inches. Back and top of head bluish black. Forehead

and lower back, dark rufous brown. Underparts light brownish and white.

14. VIREO CALIDRIS. Lady Bird.

$5\frac{3}{4}$ inches. Olive green, lighter below: top of head grayish. Dark stripe through eye, and light stripe over it.

15. EUPHONIA FLAVIFRONS. Blue Head.

$4\frac{1}{2}$ inches. Bright green, lighter and duller below. Top of head bright blue, forehead orange.

16. CALLISTE VERSICOLOR. Golden Tanager.

6 inches. Bright red-gold, appearing yellow, red, or green in different lights. Top of head chestnut: wings and tail dark green.

Female. Same, but back green, and top of head pale chestnut.

17. LOXIGILLA NOCTIS. Red throat. Sparrow.

$4\frac{1}{2}$ inches. Black: throat and line over eye chestnut.
Female. Dull brown above, gray below.

18. TIARIS BICOLOR. Grass Bird.

4 inches. Olive green: breast, throat, and forehead black.

Female. Olive green, lighter below.

19. QUISCALUS LUMINOSUS. Bequia Sweet.

$10\frac{1}{2}$ inches. Black. *Female,* grayish.

20. ELAINEA MARTINICA. Topknot. Flycatcher.

$6\frac{1}{2}$ inches. Brownish olive; throat and breast grayish; belly yellow, dirty white in middle line.

21. MYIARCHUS OBERI. Loggerhead.

$7\frac{3}{4}$ inches. Brown above, upper breast gray; lower breast and belly, sulphur yellow.

22. TYRANNUS ROSTRATUS. Pipiri.

9 inches. Gray, white below: wings and tail dark brown.

23. CHAETURA BRACHYURA. Chimney Swift Swallow.

$4\frac{1}{4}$ inches. Very dark-brown; tail and lower back gray. Never perches on branches of trees or wires; roosts in hollow trees or chimneys.

24. EULAMPIS JUGULARIS. Red Throated Humming Bird.

$4\frac{1}{2}$ inches. Black; wings and tail green; throat and breast metallic red, known by its large size.

25. EULAMPIS HOLOSERIACEUS. Emerald Throated Humming Bird.

$4\frac{1}{4}$ inches. Green, brightest on throat; blue patch on lower breast.

26. BELLONA CRISTATA. Crested Humming Bird.

$2\frac{3}{4}$ inches. Dull-green above, brown below; head with pointed metallic green crest, *Female* dull green, gray below: no crest.

27. CROTOPHAGA ANI. Tick Bird.

$12\frac{1}{4}$ inches. Black beak very much arched.

28. COCCYZUS MINOR. Cuckoo-manioc.

12 inches. Gray above, buff below: white tips to tail feathers.

29. CERYLE ALCYON. Kingfisher.

9 inches. Blue-gray above, speckled with white; white below, with blue band across breast, head with large crest.

Female with additional band on breast and sides, chestnut.

30. AMAZONA GUILDINGI. St. Vincent Parrot.

19 inches. Yellow-brown above, reddish brown bellow; head blue; forehead white; wide band of yellow and orange on wing. Tail orange at base, yellow at tip, with wide band of blue across middle.

31. STRIX NIGRESCENS. Owl. Jumbie Bird.

12 inches. Mottled brown, face reddish, buffy beneath, with small round black spots. Tail banded light and dark brownish. Ends of face feathers (ruff) dark red-brown. Iris chocolate: bill white.

32. BUTEO LATISSIMUS. Chicken Hawk Broad-winged Hawk (U. S.).

14 inches. Mottled brown above, light brown below, with dark markings on breast.

33. URUBITINGA ANTHRACINA. Black Hawk.

24 inches. Slaty black, tail banded with white.

34. FALCO PERIGRINUS ANATUM. Duck Hawk.

19 inches. Slaty gray above, dirty white below, with brown markings on breast. A powerful hawk, of great quickness and velocity on the wing. Seen about cliffs.

35. COLUMBA CORENSIS. Ramier.

13½ inches. Slaty gray, head reddish-brown.

36. ZENAIDA ZENAIDA. Mountain Dove.

10 inches. Brown above, lighter purplish brown below. Blue streak below ear. Feet red.

37. ZENAIDA MARTINICANA. Seaside Dove.

10 inches. Brown above, dull bluish-white below. Lower back chestnut. Dark-blue line on cheek.

38. COLUMBIGALLINA PASSERINA. Ground Dove.

6¼ inches. Dull-brown; spots of metallic purple on wings.

39. ORTALDA RUFICAUDA. Cocorico. Chachalaca (Mexico and United States). Guacharaca (Venezuela). Guan.

24 inches. Olive-brown, head grayish.

40. EUPSYCHORTYX SONNINII. Quail.

7½ inches. Above, mottled reddish-brown, buff, and black; tail slaty; breast, mottled grayish; rest of underparts, chestnut brown. Face white; crest and throat buff brown.

41 ARDEA HERODIAS. Gray Gaulding. Great Blue Heron (United States).

Mainly slaty gray, lighter below and streaked with white; readily known by its great size.

42. Ardea candidissima. Large White Gaulding.

White; Known by its large size.

43. Ardea caerulea. Blue Gualding. Little Blue Heron (United States). White Gaulding.

Rather small, slaty blue, neck reddish, young white.

44. Butorides virescens. Gaulding. Green Bittern (United States).

Small, grayish green, neck reddish, with white stripe down front.

45. Porzana carolina. Sora Rail.

Size of quail. Olive brown above, streaked with buff and greenish. Gray below; face black. Lives among mangrove roots and about branches.

46. Gallinula galeata. Red seal Coot. Water Fowl. Florida Gallinule (U. S.).

47. Ionornis martinica. Purple Gallinule.

Larger than preceding; green and dull purple, seal, white. Rare.

48. Fulica americana. White seal Coot. Coot (U. S.).

Larger than two preceding; dull gray; white patch under tail.

49. Anas boschas. Mallard (U. S. and England).

Large Duck (Grenada). Large. Light brownish-gray, head bright green: breast chestnut, white collar about neck; belly dirty white. A few feathers just above tail curled up, and forwards.

Female. Yellow-brown, streaked with lighter.

50. Querquendula discors. Blue-winged Teal.

Distinguished by small size and by having small feathers on wing blue.

51. Fregata aquila. Man-o'-war Bird. Frigate Bird.

Known by very large size, deeply forked tail, and long narrow wings. Colour, glossy black, young with white on breast.

52. Pelecanus fuscus. Brown Pelican.

Very large and heavy. Long beak, with pouch beneath it Brown.

53. Sula sula. Booby.

Large, but considerably smaller than preceding. Brown above, breast gray. Lower breast and belly white. Bill yellow.

54. Sula piscator. White Booby.

Same size as preceding. White, with outer large feathers of wing, and most of small feathers dark grey.

55. Phaethon aethereus. Long-tail Tropic Bird (U. S.).

Size of Chicken Hawk. White, black markings on wings. Middle tail feathers very long. Including these, the bird measures about 30 inches.

56. Larus atricella. Laughing Gull. Black-headed Gull.

Somewhat larger than preceding. Light gray above, white below. Head dark gray.

57. Sterna maxima. Royal Tern.

Larger than Tropic Bird. Tail deeply forked. Gray above, white below. Top of head black, with slight crest.

58. Sterna anosthaetus. Bridled Tern.

Top of head black. Back dark gray, lighter toward neck. White below. Forehead and line over eye white. Tail forked. Smaller than the Royal Tern.

59. Sterna fuliginosa. Sooty Tern. Hurricane Bird.

Size and general appearance of preceding, but uniform dark brown above, not lighter toward neck. White below, tail forked.

60. Sterna dougalli. Roseate Tern.

Small. Light gray above, white, with a tinge of pink below. Top of breast black. Tail very deeply forked.

61. Anous stolidus. Noddy. Mwen.

Size of Roseate Tern. Brown. Top of head light gray. Tail not forked.

62. Oceanites oceanicus. Wilson's Petrel.

Size of West Indian Martin (No. 12). Black, lower back white.

63. Puffinus auduboni. Diablotin.

Somewhat smaller than Tropic Bird (No. 55). Dark brown above, white below. Skims about near surface of water : nests in holes.

SHORE BIRDS.

64. Charadrius dominicus. Golden Plover.

65. Squatarola helvetica. Black-billed Plover. White-tailed Plover. Loggerhead.

66. Ægialitis semipalmata. Ring-Neck Plover.

67. Arenaria interpres. Turnstone (U.S. and England). Calico Bird. Rock Plover. Sandy Plover.

68. Hiniantopus mexicanus. Black Neck Stilt.

69. Gallinago delicata. Snipe.

70. Macrorhamphus scolopaceus. Dowitchu. Duckleg. Duck Bill (Barbados).

71. Micropalama himantopus. Stilt Sandpiper. Cue (Barbados).

72. Ereunetes pusillus. Semipalmated Sandpiper. Small Sandpiper (Grenada). Grass Nit (Barbados).

73. Tringa minutilla. Least Sandpiper. Cockroach Nit (Barbados).

74. Tringa maculata. Pectoral Sandpiper. October Chirps (Barbados). Grass Bird (Grenada).

75. TRINGA FUSCICOLLIS. Red necked Sandpiper. Grey Nit (Barbados).

76. CALIDRIS ARENARIA. Sanderling. Sandy Snipe (Barbados).

77. SYMPHEMIA SEMIPALMATA. Willet. White-tailed Curlew (Barbados).

78. TOTANUS MELANOLEUCUS. Greater Yellow Legs. Pika (Grenada and Barbados).

79. TOTANUS FLAVIPES. Lesser yellow Legs. Longlegs (Barbados).

80. TOTANUS SOLITARIUS. Solitary Sandpiper. Black-back (Barbados).

81. ACTITIS MACULARIUS. Spotted Sandpiper. Nit. Spotted Wag (Barbados).

82. BARTRAMIA LONGICAUDA. Upland Plover. Cotton-tree Plover (Barbados).

83. NUMENIUS HUDSONICUS. Hudsonian Curlew. Large Curlew. Crookbill Curlew.

84. NUMENIUS BOREALIS. Curlew. Chittering Curlew (Barbados).

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ST. VINCENT.

ORDINANCE NO. 11 OF 1901.

An Ordinance for the protection of certain Birds and Fishes.

Be it enacted by the Governor with the advice and consent of the Legislative Council of St. Vincent, as follows:—

Short title.

1. This Ordinance may be cited as 'the Birds and Fish Protection Ordinance, 1901.'

Offences against this Ordinance.

2. Any person who kills wounds or takes any bird or the eggs or nest of any bird specified in the first schedule to this Ordinance, or who has in his possession any such bird killed, wounded or taken, or any part thereof or the eggs or nest of any such bird taken after the passing of this Ordinance shall be guilty of an offence against this Ordinance.

Close season for birds, oysters and turtle.

3. There shall be a close season for each of the birds, enumerated in the second schedule to this Ordinance and for oysters and turtle. Such season shall, until another is appointed in lieu thereof in the manner hereinafter provided, be for birds, from March 1 to July 31, and for oysters and turtle from May 1 to August 31. *Provided* that the Governor may from time to time by notice in the *Gazette* appoint some other period or periods in lieu of the periods fixed as

aforesaid; and after any such appointment the period so appointed shall be the close season for the purposes of this Ordinance.

Governor may declare provisions of 3rd. section not applicable to any of the birds enumerated in 2nd. schedule.

4. The Governor may from time to time by notice in the *Gazette* declare that as to any of the birds, enumerated in the second schedule, the provisions of the third section shall cease to apply and may from time to time vary or cancel any such alteration; and thereupon the provisions of the said section shall cease to apply or shall again apply (as the case may be) with such variations as by the Declaration may be provided; and the Governor, may also by notice as aforesaid declare as to any bird not enumerated in the said schedule that it shall from the date of the notice be deemed to be included in the said schedule for such close season as may be named in the notice as applicable to it and may from time to time alter or amend the notice in the same way as if the bird had been enumerated in the schedule and thereupon the bird shall to all intents and purposes be deemed to be included in the schedule for the close season assigned to it in the said notice.

Governor may declare any bird not enumerated in schedule to be deemed to be included.

Killing &c. of birds, fish and turtle during close season, offence against Ordinance.

5. Except as hereinafter mentioned any person who shall kill, wound or take any of the birds enumerated in the second schedule to this Ordinance or any oysters or turtle during the close season for the same, or shall take the eggs or nest of any such bird, during the said season or shall have in his possession any such bird killed, wounded or taken or any eggs or nest taken as aforesaid or shall have in his possession any turtle or oyster during the close season for the same shall be guilty of an offence against this Ordinance.

Absolute protection on land of turtle and turtle eggs.

6. Any person who shall take or destroy any turtle or turtle eggs on land, or shall have in his possession any such turtle or turle eggs taken as aforesaid, shall be guilty of an offence against this Ordinance.

Onus of proof in certain cases to be on defendant.

7. Where any person shall have in his possession any bird, or any part of a bird, or the eggs of any bird specified in the first schedule to this Ordinance or any turtle or turtle eggs, or shall in any year after the third day of the commencement and before the end of the close season for any bird enumerated in the second schedule to this Ordinance or for turtle or oysters have in his possession any such bird, turtle or oysters or the eggs of any bird as aforesaid or any part thereof or shall in any year, after the third day after the commencement and before the end of the close season for turtle expose any turtle for sale, it shall be on him to show in answer to any charge

made against him under this Ordinance, that the bird (being one of those enumerated in the first schedule) was killed, wounded or taken or that the turtle eggs were taken before the passing of this Ordinance, or out of the Colony, or that the bird (being one of those enumerated in the second schedule) or the turtle or oysters was or were killed, wounded or taken out of the Colony or before the commencement of the close season in which he has the bird or turtle or oysters in his possession.

Offence to purchase turtle of less than 20 lb. weight.

8. Any person who shall take, kill, sell or purchase a turtle of less weight than twenty pounds shall be guilty of an offence against this Ordinance.

Mode of dealing with person found offending.

9. Where any person is found offending against this Ordinance it shall be lawful for any other person to require him to give his name, description and place of abode; and if he does not truly give his name, description and place of abode, he shall be guilty of an offence against this Ordinance, and shall in addition to any other penalty to which he is liable under this Ordinance, incur a penalty not exceeding five pounds.

Offences against Ordinance punishable on summary conviction.

10. (1) Every person guilty of an offence under the provisions of this Ordinance shall on conviction before a magistrate be liable to a penalty not exceeding five pounds and in default to imprisonment with or without hard labour for any term not exceeding three months.

(2) All proceedings for the recovery of penalties shall subject to the provisions of this Ordinance be according to any Law for the time being in force respecting the procedure before justices or magistrates.

Half of penalty to go to informer.

11. Half of any fine imposed under this Ordinance shall go to the informer.

Where offences may be heard.

12. Any offence against this Ordinance may be enquired of, heard and determined in any Police District.

Forfeiture of bird, &c., in respect of which a conviction takes place.

13. Any bird, fish, oyster, turtle, or turtle eggs, or any part thereof in respect of which a conviction takes place under this Ordinance shall be forfeited to His Majesty.

Governor may authorize killing of birds for scientific purposes.

14. Notwithstanding anything in this Ordinance, the Governor in Council may by writing under his hand for such time and subject to such conditions as he thinks fit authorize any person for scientific purposes to kill or take any bird enumerated in either of the schedules to this Ordinance or the eggs or nest of any such bird.

15. In any proceeding under this Ordinance the defendant may tender himself, and be examined as a witness in his own behalf, in the same way, and subject to the same rules as any other person. Defendant may tender himself as witness.

FIRST SCHEDULE.

Local and other names.

Cuckoo—Manioc—Rain Bird
Flycatcher
Gaulding—Grey
Gaulding—Large Blue
Gaulding—Small Blue
Gaulding—Small Green
Gaulding—White
Humming Bird, Crester—Doctor Bird
" " Green Throated
" " Ruby Throated
House wren
King Fisher
Mistletoe Bird—Yellow Breast
Mocking Bird
Molasses Bird
Pipperie—Crested
Pipperie—Hawk Beater
Redbreast
Redstart
Soufrière Bird
Tick Bird
Trembleur.

SECOND SCHEDULE.

Local and other names.

Wild Pigeon or Ramier
Mountain Dove or Tourterelle
Ground Dove or Ortolan
Every other species of Wild Pigeon or Dove
Parrot
Quail.

THE NAUDET PATENT PROCESS FOR EXTRACTING AND PURIFYING CANE JUICE.

In forwarding the following notes on a new process of sugar extaction, Mr. Robert Harvey, M.I. Mech. E., writes to the Imperial Commissioner of Agriculture as follows:—

'I herewith enclose you a sketch of a new process which we have tested in Madeira, whereby we expect greatly to increase the extraction of sugar from the cane, and, at the same time, to simplify the manufacture and reduce the amount of machinery in the factory.

I have received the order for a large plant, to treat 600 tons of cane per day, for the island of Trinidad, which should be at work about this time next year, when I trust I shall be able to publish reliable figures as regards the saving to be effected by the adoption of this process':—

This process, as applied to the cane, is designed to treat single-crushed megass, which, after extraction in the battery, is recrushed by a second mill for final use as fuel.

The process is essentially a systematic washing, or maceration of megass in a battery of eight or more cells, in combination with the filtration of the total output of juice. A centrifugal pump, exterior to the battery, constitutes an apparatus for forced filtration, and includes:—

Two pipe mains, with suction and delivery valve-connexions to each cell.

Two straining boxes, for separating cush-cush.

A compensating tank for equalizing the pressure in the cell.

Two juice heaters, worked alternately.

FILTRATION OF LIMED MILL JUICE.

Each cell, in turn, is filled with fresh megass from the cane mill whilst the equivalent yield of mill juice is being limed and heated. The hot juice, with the suspended impurities, is then added to the cell, and the latter connected to the pump. Filtration is complete in from three to five minutes, when the bulk of the mill juice can pass at once to the evaporator. This filtration is effected by drawing the juice from the bottom of a cell, pumping it through a heater, and returning it to the top of the same cell. The motion of the circulated juice is, therefore, downward through the cell of megass and upward through the exterior part of the circuit.

In the meantime, the next cell of the battery has been filled with megass, and another portion of juice limed and heated.

The pump-circuit is therefore shunted to this cell, and filtration effected as before. These operations are repeated round the battery so that the entire output of the cane mill

passes into the battery. The Naudet cells form a battery of megass filters, each of which is in operation for about five minutes, so that the filtering medium is always fresh.

MEGASS MACERATION.

In the preceding process of filtration, the two products of the cane mill are re-united in the cells of the battery, and, after the filtered juice is withdrawn from any one cell, the residual megass remains saturated with this juice. The recovery of this 'free' juice by systematic maceration immediately follows, whereby the sugar normally present in the original megass is likewise extracted. The eight cells form a circuit, the bottom of each cell communicating with the top of the next. The liquid contents of the cells can, therefore, be displaced from cell to cell round the battery, while the megass remains stationery in each cell. This displacement is effected by introducing water under pressure, and subsequently compressed air to any cell at a time. The saturated (sweet) megass, from which filtered mill juice has been withdrawn, is successively immersed in seven distinct maceration liquids (i.e., mixtures of juice and water) of diminishing densities, and finally receives fresh water to remove the last trace of sugar.

This final wash-water is then displaced, or driven forward, by compressed air into the next cell, and the exhausted megass is discharged from the bottom of the cell, and delivered to the re-crushing mill.

The new process dispenses with all existing methods of treating the juice between the mill and the evaporator. The entire output of juice is filtered, and that of the megass is macerated. The Naudet apparatus does not occupy much space and the operations, when once clearly understood, are simple and clean. Being essentially a scientific method, its successful application can only be ensured in factories where chemical control is adopted. Being also a continuous treatment, day and night work is absolutely essential.

The adoption of this process would relieve existing mills of all excessive strain, as it is quite unnecessary to exceed 65 per cent. extraction of juice by the mill. A powerful second mill is, however, required for re-crushing the wet exhausted megass when discharged from the battery.

The results of analyses of the final megass and waste-waters indicate that the loss of sugar by this new method of extraction is less than 1 per cent. on weight of cane ; and that the dilution of the normal juice is about half of that required by the usual method of maceration by spraying the megass with water between the mills.

The following additional information relating to the Naudet process, taken from the *Consular Report on the trade of Madeira* for 1902, appeared in the *Agricultural News*, Vol. II, p. 339 :—

The entire cane crop of the island last year was roughly estimated at 21,000 tons, valued at £57,000, of which amount

6,000 tons were converted into sugar and the remainder into cane spirit for local consumption. All the cane turned into sugar was manufactured by Naudet's diffusion process, and the results obtained surpassed the manufacturer's expectations. The manufactory in question is, I am told, the only cane factory in the world where this process has been tried, and by it the saccharine matter in the cane is almost entirely extracted, and the manufacturing expenses also considerably reduced.

Exhaustive experiments were made by the Naudet process for extracting the sugar which is contained in the megass or cane waste. This process has been tried with excellent results in beet factories, but had never before been attempted with cane. The Naudet patent consists in the diffusion of the megass by means of a forced circulation. The cane is crushed in the ordinary manner and the megass, which still contains a large amount of sugar which cannot be extracted by mill power, is then sent into a battery of diffusors and very nearly all the sugar is drawn by means of a centrifugal pump which sucks the sweetened water from the bottom diffusor and forces it through a special heater and thence to the top of the same diffusor. The juice is not only sterilized by being brought to boiling point but is also clarified at the same time. The difference between this and the ordinary diffusion plant is that the cane is not cut into chips but crushed, and that the megass loses none of its properties as fuel. The battery, also, instead of consisting, proportionally, of twelve to fourteen diffusors need only consist of eight or nine. By Naudet's process the juice likewise attains a higher density than by the ordinary process of manufacture.

TREATING PLANT TOPS AND CUTTINGS WITH GERMICIDES BEFORE PLANTING.

The following was published as an appendix to the *Report on the Sugar-cane Experiments in the Leeward Islands*, 1902-3 (Part I.) :—

In consequence of the views put forward by Mr. A. Howard, in a paper on the 'Field treatment of cane cuttings in reference to fungoid diseases', in the *West Indian Bulletin*, Vol. III, p. 73, experiments were made on Cassada Garden estate in treating a number of cane tops and cuttings with germicides after the manner indicated by the paper in question.

In each experiment 100 'plants' or cuttings* were planted, in addition to a series which remained untreated; three methods of treatment were adopted and the experiments stand thus:

(1) Untreated.
(2) Treated with Bordeaux mixture. (2 hours.)
(3) Ends tarred.
(4) Treated with Bordeaux mixture and the ends tarred.

Of these 100 were planted nearly vertically at such a depth that the ends were covered with mould. Another 100 were planted nearly vertically, but the ends were left uncovered. A third 100 were planted flat: thus making twelve experiments. These twelve experiments were carried out in one case with tops, and in the other case with cuttings.

Planting took place on December 29, 1902, and the number of growing plants was checked weekly from the second week after planting up to the sixth week, when observations were discontinued. The rainfall for the six weeks under experiment was 1·41 inches as follows :—1st. week, ·02 inches; 2nd. week, 0 inches; 3rd. week, ·45 inches; 4th. week, ·33 inches; 5th. week, ·24 inches; 6th. week, ·37 inches.

The results in tabular form are as follows :—

* 'Cuttings' refer to pieces of the stem of the cane which do not include the main growing point. Those portions which include the main growing point are referred to as 'tops.'

EXPERIMENTS WITH TOPS.

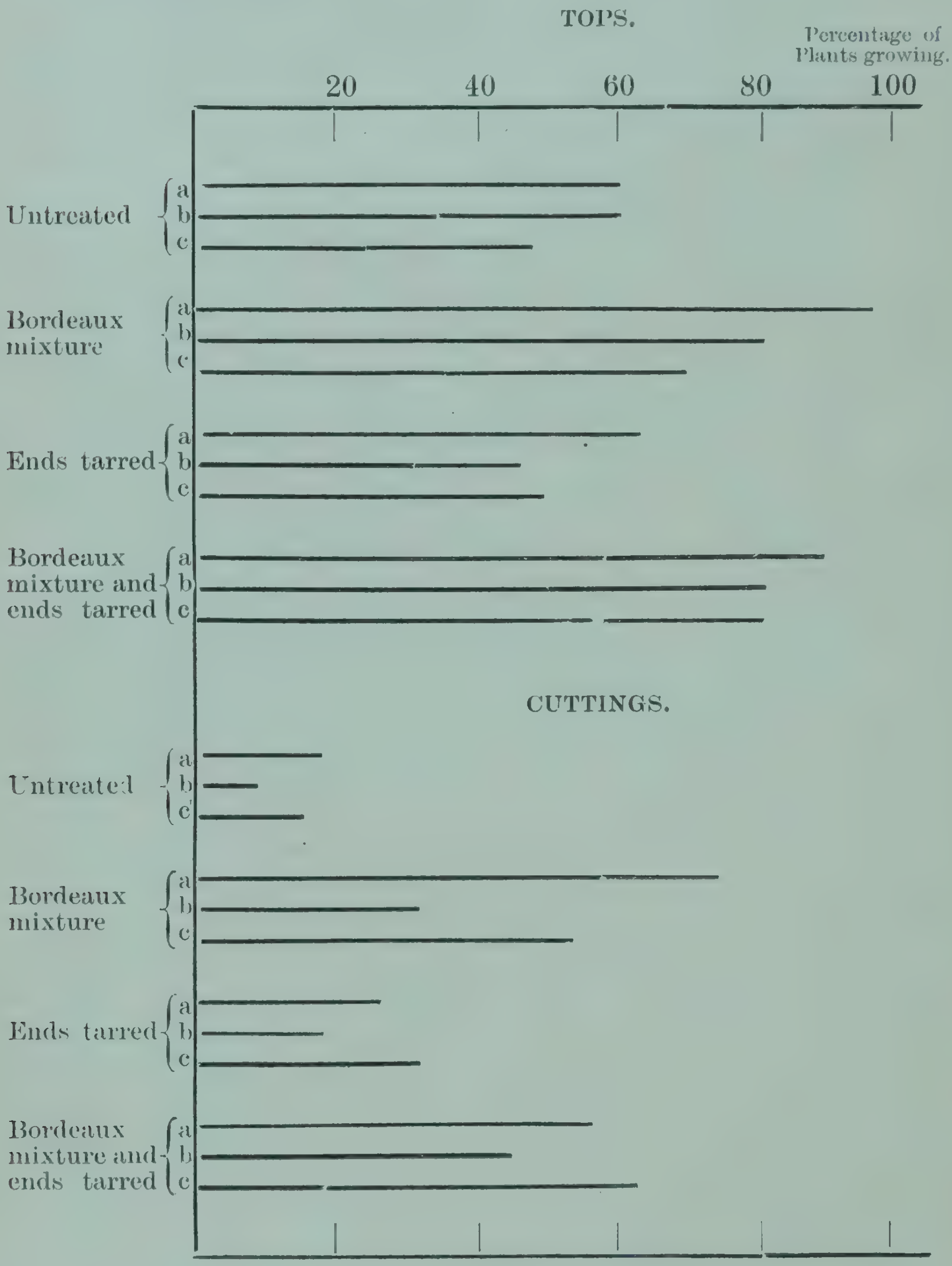
How Treated.	Ends covered, per cent. growing.					Ends uncovered, per cent. growing.					Planted flat, per cent. growing.				
	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.
Untreated	28	63	63	62	60	41	69	67	65	61	8	51	52	54	47
Bordeaux mixture	45	93	93	96	96	63	84	84	78	81	18	72	72	72	69
Ends tarred	27	54	63	63	63	18	39	42	42	45	3	57	60	60	48
Bordeaux mixture and ends tarred	54	87	87	90	90	48	78	81	81	81	27	84	87	87	81

EXPERIMENTS WITH CUTTINGS.

How Treated.	Ends covered, per cent. growing.					Ends uncovered, per cent. growing.					Planted flat, per cent. growing.				
	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.	2nd. week.	3rd. week.	4th. week.	5th. week.	6th. week.
Untreated	0	3	16	19	18	0	4	8	11	9	0	9	12	17	15
Bordeaux mixture	0	13	33	57	75	0	9	21	33	33	0	6	27	45	54
Ends tarred	0	18	12	27	27	0	6	12	15	18	0	6	15	30	33
Bordeaux mixture and ends tarred	0	12	27	48	57	0	6	15	36	45	0	21	51	60	63

The results are more striking if shown in diagrammatic form as follows, the diagrams giving the position of affairs on the sixth week after planting, the length of line being proportional to the number of plants living:—

(a) Ends covered.
(b) Ends uncovered.
(c) Planted flat.



The first thing evident is the superiority of tops over cuttings.

It is next clearly evident that in these experiments Bordeaux mixture was by far the most efficient agent in preserving the life of the portions of cane planted, and ensuring the growth of the buds.

The results may be briefly summed up thus :—

Bordeaux mixture.—This is the most efficient of the agents experimented with, its influence being most strongly marked when 'cuttings' are used for plants. Without it, i.e., of the untreated cuttings, less than 20 per cent. survived, while 75 per cent. of treated cuttings grew. With tops thus treated 96 per cent. grew, while 61 per cent. of untreated ones survived.

Tarring the ends.—This was of no benefit in connexion with tops, and of but very slight benefit with cuttings.

Bordeaux mixture and tarring the ends.—This treatment did not produce any better, or even such good results as those obtained from the use of Bordeaux mixture only.

From which we conclude that Bordeaux mixture, when used alone, is an efficacious agent in preserving cane tops and cuttings until they germinate; that the treatment is particularly useful where cuttings are used and a high mortality may be feared, and that this treatment will probably be useful when drought may be feared or where canes are planted in areas liable to fungoid attack.

As regards the manner of planting, the best results were obtained from the vertical planting where the ends were covered. Leaving the ends uncovered appears to be prejudicial, while the growth from flat planting is not so favourable, except in one case, as vertical planting with the ends covered.

FURTHER NOTES ON WEST INDIAN FODDER PLANTS.

The notes in the following pages on various West Indian fodder plants are published to supplement the paper by the Hon. Francis Watts, B.Sc., F.I.C., F.C.S., in the *West Indian Bulletin* (Vol. III, pp. 353-62). They consist of results of analyses of Jamaican fodders by Mr. H. H. Cousins, M.A., F.C.S., Government Analytical and Agricultural Chemist, Jamaica, published in the issue of the *Bulletin of the Department of Agriculture*, Jamaica, for November 1903; of extracts from the *Reports of the Agricultural Work in the Botanic Gardens and the Government Laboratory*, British Guiana; and of notes from a paper in the *Bulletin of the Imperial Institute* (Vol. II, no. I.) entitled: 'Fodder and lawn grasses suitable for cultivation in West Africa.'

In the paper in the *Bulletin of the Imperial Institute* the following introductory remarks are made on the cultivation of fodder plants:—

In all agricultural countries a regular and adequate supply of fodder for horses and cattle is a matter of great importance, and in many temperate climates a definite portion of the farm or estate is almost invariably devoted to raising grasses or other fodder, in part to supply the wants of the summer and in part to be preserved for use during the winter. In the tropics the extent to which this practice should be adopted depends largely on climatic conditions and the character and quantity available of the wild grasses. In places where there is no long-continued dry season, fresh fodder may be obtainable all the year through, and the provision of a store of food is, in ordinary seasons, unnecessary. Where, however, there are well marked wet and dry seasons, it is often as requisite to make provision for the latter as for a winter.

This is commonly effected by the preservation—as hay or ensilage—of fodder grown during the wet season, or by the cultivation of grasses which yield crops during the dry season.

The question whether hay or ensilage is the more advantageous for tropical countries is one on which opinion differs. Where the grasses to be preserved attain their most nutritious stage at the onset of the dry season, haymaking, which is simple and inexpensive, may be recommended. On the other hand, where the grasses ripen during the wet season, haymaking is practically impossible, and ensilage should be resorted to. No general rule of universal application can be laid down, the question is one to be solved experimentally for each locality with due regard to climatic seasons, the ripening periods of the grasses, and the relative expense of production, keeping power and nutritive value of the products. The second method suggested of securing fodder during the dry season, namely, by the cultivation of grasses which yield crops at that time, is one of great practical importance. On the sugar estates in Barbados, to take an actual example, a definite area is commonly maintained in a grass known locally as 'sour grass' (*Andropogon pertusus*), which thrives and furnishes excellent crops during the dry season when all other fodder is scarce. This grass . . . . . . has already been recorded from West Africa, and is well worthy of careful attention.

To turn now to the particular case of West Africa, the problems to be solved are: The provision of a supply of fodder during (1) the wet season; and (2) the dry season, the latter being either ensilage, hay, or grasses which yield crops during this time. The plants to be employed must perforce be either native or introduced, but in the first instance attention should be directed to the former, as their presence is proof of their suitability to the local conditions of soil and climate. West Africa is fortunately already well supplied with grasses of known value, and some, for example, Guinea grass, have been distributed thence throughout almost all the tropics, and are universally held in high esteem. The fact of the country possessing many wild grasses of known feeding value should not be regarded as rendering it unnecessary to take further steps to secure a supply of fodder. Adverse seasons or other abnormal conditions may render the supply inadequate, or costly, and the experience of other parts of the world has

shown that it is often more economical to cultivate the best grasses rather than to rely on indigenous sources of supply.

Wherever possible, experiments should be made to determine the feeding value of the grasses. The composition of a particular grass varies sometimes very considerably in different districts of the same country, and in collecting specimens the locality should be carefully noted with each, in the hope of ascertaining the conditions necessary to producing grass of the greatest nutritive value. When it is necessary to attempt to introduce other grasses, small plots of each only should at first be grown, at Experiment or Botanic Stations, or in other places where they will be well looked after, and preferably in as many parts of the country as possible to test their suitability to various conditions.

Having obtained by the selection of the native grasses or by the experimental cultivation of introduced grasses, a number well adapted to local conditions, of high nutritive value, palatable, and capable of affording fodder at all seasons of the year, it remains to cultivate them to the greatest advantage. When it is intended to allow cattle to graze on the grasses, hedges of some kind are usually desirable, so that the animals may be excluded at times when by too close grazing they would do harm. Trees should also be planted over the land to afford shade to the cattle during the heat of the day; one of the best trees for this purpose is the well-known saman, guango, or rain tree (*Pithecolobium Saman*), which affords a grateful shade, and in addition bears large quantities of fleshy pods much appreciated by cattle for food.

Grasses, like other crops, cannot be reaped and removed continually without impoverishing the soil, and from time to time, especially on poor soils, applications of manure will be required.

Periodical tillage and weeding will also be required to keep the land in good order and to prevent the growth of the woody weeds or 'bush' which spring up so rapidly in tropical countries. Beyond these general precautions, grass cultivation in the tropics requires no greater care than in temperate countries, but it is very important, especially in starting new cultivations, to give the preference to a grass which is hardy, and covers the ground well to the exclusion of other species, rather than to one of, perhaps, a slightly higher nutritive value, but requiring great care and attention to enable it to hold its own.

Among the grasses referred to in this paper are:—Guinea grass (*Panicum maximum*), Para grass (*Panicum muticum*), Barbados sour grass (*Andropogon pertusus*), Jamaica pimento grass (*Stenotaphrum americanum*), Bahama grass (*Cynodon Dactylon*), Jamaica sour grass (*Paspalum distichum*), and the sugar-cane (*Saccharum officinarum*).

'This list contains so many of what are regarded in other parts of the tropics as the most generally useful fodder plants that it would not appear necessary at present to seek elsewhere for other species until these have been thoroughly tested. Many of them are already held in high esteem in West Africa.

'Amongst the perennial grasses mentioned, Guinea grass is undoubtedly the most important for general purposes. It is of high nutritive value, responds readily to cultivation, is hardy, and thrives from the sea-level to elevations of 4,000 to 5,000 feet.

'Para grass is especially to be recommended as a permanent grass for swampy localities.

'In dry regions, and on poor soils, *Andropogon pertusus* and *Stenotaphrum americanum* will thrive and yield good crops, and the former will be found of great value in dry seasons, whilst *Cynodon Dactylon* will grow in such extreme situations as sand just above high-water mark, or rubbish heaps, and withstand most severe droughts.'

Mr. Cousins' results of analyses of Guinea grass (*Panicum maximum*), Para grass (*Panicum muticum*), pimento grass (*Stenotaphrum americanum*), miscellaneous pasture grasses, Spanish needle (*Bidens leucantha*), bread-nut fodder (*Brosimum alicastrum*), ramoon (*Trophis americana*), and guango or saman pods (*Pithecolobium Saman*), are as follows. The chemical analyses are all the work of Mr. H. S. Hammond, Assistant Chemist, Jamaica :—

GUINEA GRASS

(*Panicum maximum*).

This is without question the most valuable general-purpose fodder grown in Jamaica, and like most of our products shows great variation according to the district and soil upon which it is grown. Samples from five parishes have been analysed. Of these, that from St. Ann holds the first place, followed by that from Hanover. The Manchester grass shows an inferior quality, while that from St. Mary, although considered a good grass for the district and genuine Guinea grass, is decidedly the most inferior of the five.

The grass from St. Mary is little better than good oat-straw in feeding value, while such grass as that obtained from St. Ann is quite equal to good timothy grass in general feeding value.

The effect of irrigation, manures and the period of ripening have still to be ascertained. There is evidently a reductiou in the amides, owing to their elaboration into the more valuable albuminoids, with the ripening of the plant, although this is probably associated with an increase in the 'bone' or indigestible stem and fibre of the grass.

Guinea grass is most susceptible to manuring, and where grass is valuable it should pay to treat the grass pieces liberally in this respect when they show signs of exhaustion.

ANALYSES OF GUINEA GRASS.

	Hay. Sun Dried.					Dry Matter at 100° C.				
Number.	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.
Parish.	St. Mary	St. Ann	Hanover	Westmoreland	Manchester	St. Mary	St. Ann	Hanover	Westmoreland	Manchester
Moisture	14·20	16·31	13·04	13·83	10·49	—	—	—	—	—
Fat, wax, etc.	0·26	1·16	0·20	trace	0·11	0·30	1·38	0·52	trace	0·12
Albuminoids	3·50	4·55	4·29	4·37	3·41	3·47	5·44	4·93	5·08	3·81
Amides	0·48	2·10	1·59	0·47	1·09	0·61	2·50	1·95	0·54	1·22
Total nitrogenous matter	3·98	6·65	5·88	4·84	4·50	4·08	7·94	6·88	5·62	5·03
Carbohydrates	42·07	36·46	36·99	36·90	41·88	49·39	43·58	39·08	42·82	46·70
Crude fibre	31·63	33·71	34·99	36·34	36·35	36·86	40·28	39·87	42·17	40·70
Ash	7·86	5·71	8·80	8·09	6·67	9·37	6·82	7·66	9·39	7·45
Potash	Note.	Nos. 1, 2	& 3 were	cut before flo	wering.	0·17	0·10	0·67	1·95	1·12
Lime		Nos. 4 & 5	were cut	when just in flower.		0·50	0·93	0·39	0·99	0·49
Phosphoric acid ...						0·30	0·43	0·44	0·62	0·41

PARA GRASS

(*Panicum muticum*).

Constituents.	A. St. Ann.		B. Hanover.	
	Sun Dried.	Dry.	Sun Dried.	Dry.
Moisture	12·57	...	14·91	...
Fat, wax, etc.	0·80	0·91	0·44	0·52
Albuminoids	5·64	6·44	5·85	6·87
Amides	1·57	1·81	5·13	6·03
Total nitrogenous matter	7·21	8·25	10·98	12·90
Carbohydrates	40·66	46·51	33·25	39·08
Fibre	33·08	37·83	33·93	39·87
Ash	5·68	6·50	6·49	7·63
Potash	...	0·50	...	0·70
Lime	...	0·90	...	0·40
Phosphoric acid	...	0·47	..	0·44

Here again we see marked variation in the composition of the same grass grown in two different situations and districts. The Hanover Para grass shows a very high feeding quality. For growing stock and milk production the Para grass shows a decided superiority to the Guinea grass grown under the same conditions. The nitrogenous constituents are in a most favourable proportion. This grass is undoubtedly of high value in those districts to which it is well suited.

PIMENTO GRASS

(*Stenotaphrum americanum*).

Constituents.	Dried at 100° C.	Sun Dried.	Green.
Moisture	...	15·75	80·78
Fat, wax, etc.	1·64	1·38	0·32
Albuminoids	7·25	6·12	1·38
Amides	1·37	1·14	0·28
Total nitrogenous matter ...	8·62	7·26	1·66
Carbohydrates	48·58	40·93	9·33
Fibre	33·13	27·91	6·37
Ash	8·03	6·77	1·54
Potash	0·76	...	...
Lime	0·66	...	...
Phosphoric acid	0·58	...	...

This grass came from St. Ann and does not compare with either of the two preceding species as a source of large crops of luxuriant growth. It is, however, a valuable common grass. This sample appears to be slightly inferior in feeding quality to the common grass of the same species from Westmoreland, of which Mr. Cradwick speaks so highly.

MISCELLANEOUS PASTURE GRASSES FROM WESTMORELAND.

Constituents.	Common Grass. (In flower.) A.		Common Grass. (In flower.) B.		Corn Grass. (Flowering.)	
	Sun Dried.	Dried at 100° C.	Sun Dried.	Dried at 100° C.	Sun Dried.	Dried at 100° C.
Moisture	13·19	...	13·03	...	11·95	...
Fat, wax, etc., ..	1·08	1·24	0·49	0·57	1·36	1·55
Albuminoids	8·02	9·24	8·36	9·61	7·77	8·82
Amides	1·23	1·42	0·33	0·39	1·58	1·80
Total nitrogenous matter	9·25	10·66	8·69	10·00	9·35	10·62
Carbohydrates ...	42·22	48·64	43·45	49·95	35·37	40·17
Fibre	27·52	31·70	27·24	31·32	32·73	37·17
Ash	6·74	7 76	7·10	8·16	9·24	10·49
Potash	..	1·34	...	1·12	...	2·07
Lime	...	0·48	...	0·48	...	0·76
Phosphoric acid ...	...	0·69	...	0·73	...	0·57

With reference to the 'Common grass', of which he sent two samples, Mr. Cradwick writes :—

'This is the best permanent pasture, probably, in the world. I have a filly which gets 5 quarts of corn or oats a day and the tenth share of about 3 acres of this pasture and is as fat as a mole ; she works as a rule three or four days a week, and is always in show condition. Commons around Knockalva are

equal to Guinea grass if kept clean, which very few are, I am sorry to say, always, of course, excepting Knockalva.'

And with reference to 'Corn grass':—

'A very fine feeding for young brood, and out-of-condition stock; nearly as good as Spanish needle.'

SPANISH NEEDLE

(*Bidens leucantha*).

Constituents.	Dried at 100° C.	Sun Dried.	Green.
Moisture	...	15·83	90·01
Fat	1·54	1·30	0·15
Albuminoids	10·91	9·19	1·09
Amides	0·91	0·76	0·09
Total nitrogenous matter ...	11·82	9·95	1·18
Carbohydrates	33·56	28·24	3·36
Fibre	38·34	32·27	3·83
Ash	14·74	12·41	1·47
Potash	3·80	...	...
Lime	1·64	...	...
Phosphoric acid	0·54	...	...

Mr. Cradwick who sent this sample writes:—

'I find from actual experience that Spanish needle is splendid feeding for horses off condition, picking them up very rapidly; it acts as a slight purgative and for a horse in poor condition suffering from worms, etc., is a wonderful fodder. All horses eat it greedily.'

The analysis supports this claim. The proportion of flesh-producing albuminoids is high, decidedly in excess of any of the fodders previously reported upon. This plant grows freely in many banana plantations in St. Mary and would form an admirable addition to the local Guinea grass as a food for stock. It has been found excellent as a green manure on banana properties.

BREAD-NUT FODDER

(*Brosimum Alicastrum*).

Constituents.	Dried at 100° C.	Sun Dried.	Green.
Moisture	...	15·86	61·08
Fat, wax, etc.	3·15	2·62	1·23
Albuminoids	10·69	8·99	4·16
Amides	3·62	3·05	1·41
Total nitrogenous matter ...	14·31	12·04	5·57
Carbohydrates	49·22	41·45	19·15
Fibre	25·57	21·51	9·05
Ash	7·75	6·52	3·02
Potash	0·72	...	..
Lime	1·08	...	...
Phosphoric acid	0·50	..	...

This is a valuable fodder-product. It is, for a tropical fodder, unusually rich in nitrogenous matter and deservedly holds a high place as a food for stock. The sample came from St. Ann where it grows freely.

RAMOON

(*Trophis americana*).

Constituents.	St. Ann.		Westmoreland.	
	Sun Dried.	Dried at 100° C.	Sun Dried.	Dried at 100° C.
Moisture	14·12	...	11·60	...
Fat, wax, etc.	5·04	5·87	4·10	4·63
Albuminoids	8·49	9·89	12·30	18·91
Amides	1·15	1·34	2·22	2·51
Total nitrogeneous matter	9·64	11·23	14·52	16·42
Carbohydrates	41·61	48·45	38·96	44·08
Fibre	22·74	26·48	19·47	22·03
Ash	6·85	7·97	11·35	12·84
Potash	..	0·78	...	1·63
Lime	...	1·12	...	2·31
Phosphoric acid ...	...	0·51	...	0·45

Two samples of ramoon, representing the leaves and young twigs of *Trophis americana* from St Ann and Westmoreland are here compared. It is striking that the ramoon from the latter parish is very greatly superior as regards nitrogenous constituents. This fodder holds pride of place in this series and must be considered of high nutritive value.

Mr. Cradwick, who sent this premier sample from Westmoreland writes: 'This is a fine stimulating and strengthening fodder. A little ramoon and plenty of common grass form, from my experience, an ideal feed for horses and mules.'

RICE MEAL.

	Per cent.
Moisture	14·11
Fat	0·23
Albuminoids (crude)*	6·12
Carbohydrates	35·04
Fibre	31·32
Ash	13·18

*Containing amides ... ... 0·43

The above analysis is that of a sample of rice meal from Mr. Walter Woolliscroft, of George's plain, Westmoreland, who has established the rice industry on that property. This product is readily eaten by horses and should be regarded rather as a substitute for corn than for oats, since it is by no means rich in nitrogenous constituents.

GUANGO

(*Pithecolobium Saman*).

Constituents.	Seeds.		Pods.	
	Natural.	Dried at 100° C.	Natural.	Dried at 100° C.
Moisture	13·46	...	20·46	...
Fat, etc.	5·15	5·95	0·56	0·71
Albuminoids	18·09	20·95	8·95	11·25
Amides	9·25	10·69	1·22	1·54
Total nitrogenous matter	27·34	31·59	10·17	12·79
Glucose	0·36	0·42	7·12	8·95
Total carbohydrates ...	38·20	44·15	55·35	69·59
Fibre...	12·10	13·98	11·55	14·51
Ash	3·75	4·33	1·91	2·40
Potash	...	1·52	...	1·40
Lime	...	0·22	...	0·04
Phosphoric acid... ...	...	0·77	...	0·74

An analysis of the guango, as made by Professor J. B. Harrison, of Demerara, was published in the *Bulletin of the Botanical Department*, 1901, p. 154. This, as the analyst has since pointed out, ignored the fact that cattle and horses only digest the pods, while the seeds are excreted entire.

In a recent report Professor Harrison has published separate analyses of the seed and the pods, and although the Demerara guango varies greatly from that grown in the Liguanea plain in Jamaica, the main point is brought out by both analyses that the pods are greatly inferior to the seeds in nitrogenous matter and that, in practice, the guango is by no means so rich a nitrogenous food as would appear from the composition of the entire fruit, seeds and pod. Our samples averaged pods to seed as 5 to 1.

The pods contain a good deal of glucose and a moderate proportion of albuminoids only. Could the seeds be ground up, a high-class cattle-feed should result. One of the difficulties is that of the sticky consistency of the pulp of the pods, which would make the process of milling somewhat difficult. It is probable, however, that if the pods were thoroughly dried before being milled, a satisfactory result would follow.

Mr. J. Barclay, Secretary of the Jamaica Agricultural Society, has forwarded the following memorandum regarding guango:—

'Trees drop their leaves in January.

'Fruit ripens March to May ; drops when fully ripe unless it is blown off by breeze. Eaten greedily by cattle and horses ; latter, as with mangos, reject most of the seed in chewing, but former eat all, and seed passes through, and the droppings a month later may be seen covered with sprouting seedlings. This is by far the best way indeed to establish a nursery of young plants to secure young seedlings.

'Guango is a rich and cloying food, and when any other fodder is available cows and horses will as a rule, only eat a little at a time, then go to drink and eat something else. When plenty of water is available at will for stock, they may live on it almost entirely for a month to two months, drinking freely all the time, but if water is scarce the seeds may then block the stomach or intestines and cause illness ; but as the guango does not last in season very long and ceases with the rains, a diet, chiefly consisting of it, is not generally continued long enough to do harm, as the young springing grass following is very laxative in effect. Some people (and it ought to be done to a much wider extent that none should be wasted) gather the guango and store it, feeding it for months after it is out of season. Tons of it, however, are wasted, and stock keepers, buying corn and oats at 5*s.* a bushel, crush the valuable pods under their feet every day. There is a difficulty in curing it because of its saccharine content easily causing fermentation when it is stored, and it does not dry up and cure like corn, exposed to the sun in the pod. The remedy I think is to crush it and dry it into a meal, and it needs a hot dry place to do this quickly. An artificial drier should work best.'

The *Report on the Agricultural Work in the Botanic Gardens*, British Guiana, for 1890, gives further information with regard to the feeding value of this tree and contains the following analyses of the fruits of saman:—

	In fresh state.	Dried at 130° F.
Water...	54·08	9·26
Glucose	10·85	21·45
Gums, pectose, etc. ...	8·89	17·58
Albuminoids (*a*) ...	7·30	10·44
Oils, fats, etc. ...	0·76	1·51
Starch and digestible fibre	13·73	27·07
Indigestible fibre ...	2·96	5·85
Mineral matters ...	1·43	2·84
	100·00	100·00
(*a*) Containing nitrogen...	1·16	2·31

In composition the beans of this tree, which has become common in the colony in the last ten years for avenue and shade purposes, have about the same value for cattle food as the carob beans (*Ceratonia Siliqua*) of the Mediterranean region, which are largely used for the purpose. They appear to be very palatable, and are eaten voraciously by horses, cattle, sheep and goats, which, when they approach a tree, where the pods are dropping, run about eagerly searching for them in the grass. If gathered and kept free of damp, they may be stored for a considerable length of time without change of condition. In the dry districts of Jamaica, where the trees are plentiful, such as that about Spanish Town, they are gathered as they drop and stored in barrels, till, in the course of the season's drought, the pastures dry up and become devoid of herbage, when they are brought out and given to the cattle to eat. Though very sweet to the taste, the sugar they contain is not of a crystallizable nature.

In the *Report* for 1896-1902 the following note on this tree occurs:—

In the *Report* for 1890 the composition of the fruit of the saman tree was given. It has been pointed out to us that the figures given in that analysis are somewhat misleading, as they relate to the whole fruit, including the hard seeds which are voided in their entirety after the pods have been eaten by cattle. The following analyses were therefore made to show the composition of the seeds and of the flesh of the fruit in their fresh state:—

	Seeds.	Flesh.
Water	16·67	63·02
Fat	5·49	·37
Albuminoids (*a*)	24·17	3·27
Glucose	1·57	13·07
Pectose, etc.	8·59	8·97
Digestible fibre	30·77	8·92
Woody fibre	9·23	1·46
Mineral matter	3·51	·92
	100·00	100·00
(*a*) Containing nitrogen ...	3·87	·32

The flesh of the fruit is evidently of considerable nutritive value as regards its contents both of albuminoids and of digestible carbohydrates. The seeds, if finely ground, would form a concentrated cattle food of fairly high value.

FRUIT OF CALABASH

(*Crescentia Cujete*).

Water	90·99
Fat	0·14
Albuminoids (*a*)	0·81
Amides, etc.	—
Glucose	0·93
Gums, pectose, etc.	0·93
Starch and digestible fibre ...	4·33
Woody fibre	1·35
Mineral matters	0·52
	100·00
(*a*) Containing nitrogen ...	0·129

A fruit of low food value owing to its high proportion of water. It is readily eaten by cattle and forms a valuable adjunct to the food of milch cows from its succulent nature. To be used for this purpose, the fruit must be cut when about half grown before the shell and seeds have hardened, and be sliced before feeding to stock. It does not appear to be generally known that calabashes are valuable for this purpose, so great a quantity everywhere is allowed to perish. There are several kinds varying chiefly in size and shape. (*Report on Agricultural Work*, British Guiana, 1893-5, p. 127.)

PHASEOLUS SEMIERECTUS.

The following figures were obtained by the analyses of samples of the fresh plant and of the seeds :—

	Plants.	Seeds.
Water	78·78	9·92
Fat	·52	2·00
Albuminoids (*a*)	1·18	16·85
Amides (*b*)	1·25	5·08
Saccharose	—	10·96
Glucose	·36	2·94
Gums, etc.	3·01	·70
Starch	—	17·43
Digestible fibre	7·77	19·44
Woody fibre	6·27	11·32
Mineral matter	·86	3·36
	100·00	100·00
(*a*) Containing nitrogen	·189	2·70
(*b*) Containing nitrogen	·200	·81
Total nitrogen ...	·389	3·51

This leguminous plant grows commonly in British Guiana on abandoned fields and in pastures where not overshadowed by other plants. Examinations of its roots have shown that they possess root-nodules in far greater proportion than do those of

any of the various kinds of cow peas which we have examined here. From its mode of growth, and more especially on account of the woody nature of its stems, it is not so suitable for ploughing into the ground as a green dressing as are certain of the varieties of the latter.

Its composition indicates that it is a very nutritious plant, and cattle are exceedingly fond of it. The coolie grass-cutters always select this plant where obtainable as fodder for their cows. We found that on land at the gardens, where it became practically self-sown, without special cultivation, it gave two crops per annum, yielding 27 tons of green fodder per acre. (*Report on Agricultural Work*, British Guiana, 1896-1902.)

BAHAMA GRASS

(*Cynodon Dactylon*)

We extract from the article in the *Bulletin of the Imperial Institute* the following notes on *Cynodon Dactylon*, a grass of very common occurrence in these islands :—

This grass has a very wide distribution, occurring in many tropical, sub-tropical and even temperate regions. It is known in various localities by a large number of names, amongst those most generally in use being Bermuda grass (U.S.A.), Bahama grass, Devil grass (West Indies), Durba (Bengal), Dub or Doub (N. India). Without doubt it is a useful and valuable grass, growing freely on poor soils and waste places where other grasses will not thrive, and having a remarkable power of withstanding protracted droughts.

'In the Southern States it is the most important grass for pasturage, and in Hindustan it is prized for fodder both for horses and cows.'

Bermuda grass is a creeping, perennial grass, rooting at every node, and forms long, wiry, underground stems. It varies in height from about 2 inches on poor ground to about 2 feet on good soil.

The underground stems render it very resistant to drought, but at the same time make it very difficult to eradicate in places where it has become established. For this reason it should only be grown where it is to remain permanently.

The following analyses of this grass are recorded by the United States Department of Agriculture :—

	Fresh, per cent.
Water	14·3
Ash	7·8
Fat	1·3
Nitrogen free extract (starch, sugar, etc.) ...	45·0
Crude fibre	19·9
Albuminoids	11·5

COLD STORAGE FOR FRUIT.

At the present time the subject of the transport of fruit, more especially bananas, is receiving considerable attention in the West Indies. The banana industry in Jamaica has reached large proportions; in the island of Trinidad efforts are being put forward to start a banana trade on similar lines; while in Barbados the shipment of bananas may now be said to have passed the experimental stage.

At the outset, in the establishment of such industries, there are certain to be difficulties. Among the chief of these are getting the fruit picked at the right stage, handled carefully, and packed properly. Matters of this sort have already been dealt with in the *West Indian Bulletin*, in the paper by the Hon. Wm. Fawcett, B.Sc., F.L.S., on the Banana Industry in Jamaica (Vol. III, p. 153), and also in the report of Mr. W. E. Smith, of Trinidad, published in the present volume (p. 53).

It is quite understood, however, that, although careful handling and packing of bananas are essential to their successful transportation, proper attention must be paid to the conditions under which they are to be carried on board ship.

One of the difficulties in the way of the establishment of a fruit trade between the West Indies and the United Kingdom has been the fact that, in the case of some of the islands at any rate, the steamers of the Royal Mail Steam Packet Co. have been the only means of shipment available, and these have not, of course, been specially constructed for the fruit trade. Moreover, the requirements of the different islands, in connexion with the carriage of fruit, have not been by any means identical.

With the view of making available to fruit growers in these islands the opinions of experts connected with the fruit trade, as representing the most recent information on the subject of the transportation of fruit, we publish extracts from correspondence between the Union-Castle Mail Steamship Company, Limited, and their Cape Town Agency, which was recently published in the Cape of Good Hope *Agricultural Journal.*

In this correspondence will be found the opinions of managers of large fruit concerns in the United States, who give their experiences in connexion with various matters relating to the carriage of fruit.

The whole correspondence gives a fairly complete account of the subject and contains much valuable information:—

The Union-Castle Mail Steamship Company, Ltd.—to Cape Town Agency.

We have given this matter our very careful consideration, and with a view to having all the information possible before us we have asked Captain McLean Wait (our representative in New York) to ascertain the practice in New York, both in regard to the shore refrigerators, the carriage on the railways, and the refrigeration in the steamers running to and from New

York. We have now received his report upon cold storage and the carriage of fruit in refrigerated cars by railway.

Mr. Molteno has also considered the matter in the light of his experience at the Cape, and the experience of the shippers with the results during the past season.

We are thoroughly convinced that the troubles which have arisen in regard to the failure in the case of grapes, and to a limited extent in the case of other fruits, have been due to the fact that the fruit, either when packed or during transit, or by lying in the sun at the stations or at the docks, has been allowed to attain a considerable temperature, and no amount of refrigeration afterwards has been able to remedy this original fault. Mr. Molteno had come to this conclusion independently of the information from New York, but you will observe that the greatest stress is laid upon this point, both by Captain McLean Wait and by the gentlemen whom he interviewed.

The matter is so important that we quote Captain McLean Wait's words: 'The point which struck me most during the inquiries I have made, is the great stress which everyone lays upon keeping the fruit cool for packing, and during transit to refrigerators. Nearly all the failures to out-turn successfully appear to have arisen from neglect in taking this precaution.' Further, in the interview with Mr. Thurston, where details will be found of the manner in which the fruit is kept cool, out of the sun, and only packed late in the evening when the temperature has fallen to the minimum, he says : 'Mr. Thurston regards the cooling off of the fruit, prior to packing, as an absolute essential to successful delivery.' He says that if the fruit is packed during a hot day, when it would naturally retain heat, no amount of after-refrigeration will have the necessary preservative effect, because, although the outside of the fruit may be apparently cool, still, the inside having retained the heat, a process of decay is set up under refrigeration.

There are other details in the report itself to which we would refer you, such as the character of the sheds in which the fruit is packed, and the best temperature at which it should be maintained.

You will recollect that Mr. Dicey pointed out that his fruit had carried without refrigeration on the railway, but in the cool chamber it had failed. The explanation is that in transit to the refrigerator the boxes of fruit had become thoroughly heated, and the refrigeration afterwards had failed to remedy this prime defect.

You will observe that in all the handling of the fruit everything is arranged so that the heat may be avoided as much as possible, in fact, the transfer of the fruit is carried out at night, as well as from the car to the ship, the fruit going direct from the refrigerator car to the ship's refrigerator.

With regard to the use of fans, upon which Mr. Pickstone expressed an opinion, we have gone into this question and we are of opinion that fans are only used where the position of

a battery of pipes is such as to necessitate the use of a fan for passing air over the pipes before passing it into the chamber, or even in the chamber itself; but where pipes are arranged around, or at the two ends of, the chamber, this is not necessary, and we cannot see any advantage in putting fans in chambers so completely supplied as are those of our steamers.

We are giving very careful consideration to the question of the proper stowage n our cool chambers, and new instructions are being prepared for all the engineers with special observations on particular arrangements in individual ships. These will be useful for the shore refrigerator also.

We shall also be sending out to Mr. Burman very carefully considered instructions in regard to the mode of stowage to be adopted so as to ensure a complete circulation and the maintenance of a uniform temperature in every part of the refrigerator.

From what we have said, and from Captain McLean Wait's report, you will perceive the immense importance of having the fruit properly dealt with before it reaches our cool chamber, or even the cool chamber in the docks; but we think it of great importance that you should get the Horticultural Board and the Fruit Export Association to agree to have the fruit placed, for at least two days before being shipped, in the shore refrigerator, and this rule should apply to all fruit.

We think the attention of the Cape Orchard Company and Mr. Pickstone should be drawn to the considerations which we have advanced above, and we have no objection to their having a copy of the enclosed reports, and, if you think fit, of this letter of ours.

We think some interest should be taken in the management of the refrigerator on shore with a view to seeing that the proper temperature is really observed, with the proper stowage so as to admit of the free circulation of the air at the bottom and round all the cases being possible, and the stowage in the shore refrigerator should be as loose as is possible, consistent with the space at your disposal. It would be the greatest mistake to cramp the fruit in the shore refrigerator.

We presume that it can be arranged for the transfer of fruit from the refrigerator on shore to the ship's refrigerator in a way that will avoid it being done in the sun and with as little delay as possible.

Mr. De Koch, of 'The Vines,' Constantia, has recently left for the Cape. He saw the fruit here during the season, and was much impressed with the bad packing and poor quality of some of the fruit. He is a member of the Constantia Fruit Growers' Association. Mr. Van Breda, of Hauptville, Constantia, also takes an interest in this question, and can tell how fruit has been in the sun before going on to the railway, and also as to bad packing. It would be useful if more air holes could be given to the cases with grapes, packed with wood wool.

Copy of the enclosed reports should be given to the Horticultural Board and the Fruit Export Association, with extracts from this letter.

Captain McLean Wait—to the Union-Castle Mail Steamship Company, Ltd.

In reply to your letter of August 19, I beg to hand you a memorandum of interviews (and inspections) which I have had with (1)—Erie Railway West Freight Department, (2)—Merchants' Refrigerating Company, (3)—Manhattan Refrigerator Co., (4)—Mr. C. E. Thurston, Fruit Agent, Jay Street, New York. I had also hoped to examine one or two vessels belonging to the Fruit Despatch Co., and the United Fruit Co., of this city, but have not been successful this week. I will endeavour to do so next week, and write you further.

I also have the pleasure to hand you a pamphlet, 'Cold Storage,' published in New York in April of this year, which contains, among other things, a very good description of the fire-proof cold store recently erected by the Merchants' Refrigerating Co. in Jersey City. This is a magnificent installation, and is extremely well kept.

Fans in Refrigerators.—The writer learns that, up to the present, opinions are much divided as to the utility and practical value of fans in refrigerators. You will notice that while the Merchants' Refrigerating Co. avoid their use, the Manhattan Cold Storage Co. (also a large concern) think there is nothing like them. The Arctic Cold Storage Co., in West Street, do not use fans. This is a comparatively small establishment; while the Riverside Cold Storage Co., which is, I am informed, about the same size and capacity, do use them, with an expansion machine, whereby no pipes are placed in the chambers, but the cold air is driven from the various concentration bunkers into the storage rooms.

I cannot find, up to the present, that any fans are used in either refrigerating cars, or in steamers' refrigerators, but I hope to be better posted next week with regard to the latter.

The point which struck me most during the inquiries I have made, is the great stress which everyone lays upon keeping the fruit cool for packing and during transit to refrigerators. Nearly all the failures to out-turn successfully appear to have arisen from neglect in taking this precaution.

Interview with Mr. C. A. Thompson, Manager of Erie Railroad West Freight Department.

This railway brings nearly all the California fruit to New York, and is daily handling very considerable quantities. For instance, the day on which the writer made his inspection the company were dealing with forty cars, each averaging about 25 tons measurement.

The cars, for the most part, are built at Chicago, either by the American Car and Foundry Company, or the Wells and French Company: the price the subscriber could not actually get at, but was informed they cost about $10,000. Some carry 25 tons measurement, and some 35 tons measurement. The insulation is cow hair. Each car is fitted with double air-

tight hinged doors in the centre of the sides, the cars are cooled by means of ice bunkers placed at each end, and filled from the top. The ice is not allowed to go right to the floor, but the bottom and top of the bunker are so constructed that a current of air is in constant circulation. The capacity of each bunker is from 1 to $1\frac{1}{2}$ tons, in accordance with the size of the car.

Fans.—There are no fans ever used in the cars. There are two overhead ventilators at each end above the ice bunkers, size about 18 inches square. The temperature kept is from 36° to 39° F.

The time occupied in transit, from the time of the shipment of fruit in California to the time of delivery in New York, is about seven days. Along the track at certain stations supplies of ice are held, by means of which the ice bunkers are replenished as required.

Stowage of Fruit.—The cases are stowed in such a manner that the cold air can have access to each package. In order to accomplish this, it is necessary to use a good deal of light wood for shoring off the packages, and for building the lane and alleyways by means of which the air can fully circulate.

Discharge of Cars.—This is always so arranged that the heat may be avoided as much as possible. The general custom is to commence work about 1 o'clock in the morning, and endeavour to get finished at 7 o'clock at the latest. The fruit is discharged into an open-sided shed at the Erie Company's premises, Pier 20, New York, and is stacked, in accordance with marks, in blocks and alleyways so that the buyers can easily walk round. The lids of the top tiers of each consignment are opened, and the fruit exposed for inspection. The dealers are supplied with a printed catalogue from which they can make their selection, and the fruit is sold from 8 o'clock to about 11 o'clock, at which latter hour the auction is generally finished. The auction room is in the upper part of the building on the pier, so that there is no delay to the dealers. The writer was informed that by 2 o'clock in the afternoon the quay was clear of the morning's fruit.

Great stress is laid on keeping the temperature to the proper mark all the way along the track, and also on the manipulation of the car ventilators in accordance with the state of the weather. The Railroad Company act upon the desire and instruction of the fruit shippers with regard to the temperature to be kept.

Mr. Thompson says that there is a movement on foot to cool the cars electrically, but at present it has not been taken up with any enthusiam owing to difficulties which might occur if the train was side-tracked, or when accidents happen, which are fairly frequent in causing delays.

The transference of the fruit for exportation from car to ship is dealt with very rapidly. The work is carried on during the cool of the evening, and the fruit goes direct from the car to the ship's refrigerator.

Interview with Mr. John Burgess, Manager of the Merchants' Refrigerator Company, North Moore Street, New York.

This gentleman is in charge of a very large installation of cold storage plant in New York, a building of eight stories in height, and capable of cooling 10,000 tons of produce at 40 cubic feet. This company have also another and larger fire-proof storage house in New Jersey, capable of dealing with 87,500 tons at 40 cubic feet, a description of which is now enclosed. The establishment over which Mr. Burgess presides, in North Moore Street, has been running for about thirteen years. It is fitted with the latest design of Heine's safety water tube boilers, and a Pontifex absorption brine circulator, built at Carbonndals, Pa., and also has one of the Isbell-Porter Company's polar absorption machines (a design of which is shown on page 191 of the pamphlet), built at Newark, New Jersey, both of which, Mr. Burgess says, give excellent economical results.

The staff required to keep up the boiler and engine department is three engineers and three firemen. The store is fitted with elevators throughout, some of which are insulated ante-rooms of same pattern as those entirely used in the newer building in New Jersey.

A complete installation of electric light is installed throughout the building, and the goods are handled on the floors in specially constructed trucks, which not only reduce the labour, but prevent undue shaking and knocking about of the contents of packages, such as eggs, fruit, etc.

Use of Fans.—Mr. Burgess is not favourable to the use of fans in the chambers; he does not see the necessity for them. The writer went through the whole of the rooms, and they were beautifully dry and sweet, and his attention was drawn to the consignments of butter and cheese, which had been stored for over five months and kept in a uniform temperature the whole of the time, and Mr. Burgess had not the slightest anxiety but that they would come out just as fresh as the day they went in. Temperature, 26° F.

Piping.—The system of piping is shown on page 159 of the pamphlet.

Cross over-head piping is not used. The insulation is fire-proof, and is obtained from iron filings specially treated.

Temperature.—Mr. Burgess handles meat, poultry and game at about 10°, eggs at 31°, apples and pears at 34°, and other soft fruits at about 36°, but these latter never remain very long in the chambers. He also lays very great stress upon the condition in which fruit, butter, meat, etc., are received for refrigeration, and insists that the heat must be out of the articles before they can be preserved in the chambers successfully.

Uniform Temperature.—An absolutely uniform temperature is also essential and great care is taken to maintain this. Each room is fitted with an automatic circular temperature indicator (or clock), and the writer examined numerous cards,

each showing a week's work. These were beautifully uniform and pointed to the fact that the cooling plant was able to be manipulated to a great nicety.

Mr. Burgess had no experience of the storage of grapes, but seemed to think that a temperature of about 30° to 40° ought to give good results, but he laid great stress on the age of the fruit when it was received for cooling. The writer was very much struck with the absolute cleanliness of the chambers, and the entire absence of odour, or leakage of any sort.

Interview with Mr. Herbert C. Stone, in charge of the Manhattan Refrigerator Company, West and Horatio Streets, New York City.

This is a large refrigerating establishment, capable of dealing with about 5,000 tons of all kinds of stores. The writer was taken into various rooms, and saw under refrigeration and cool storage, meat, game, etc., butter, eggs, fish in barrels, dried and fresh fruits of all kinds (with the exception of grapes and peaches), vegetables of all kinds, and floral produce such as bulbs of lily of the valley, Japanese lily bulbs, and others of a such like nature.

The building is constructed with eight floors, and insulation is mineral wool. The process used is the ammonia and brine system, put through pipes placed in what they call 'bunkers' in each chamber, that is, the pipes are concentrated into one spot, and not fitted all round the chambers. Under this system, which applies only to those rooms where it is necessary to keep the temperature from about 30° upwards, 12-inch electric fans are used to effect a uniform temperature.

Position of Fans.—These are placed near the floor and close to the cooling pipes; and direct the air upwards to the roof, below which is placed a kind of false ceiling with fairly close-fitting slat openings. The cold air finds its way through these and by gravity descends, thus ensuring the equal distribution of cold air all over the chamber. The manager was very strong on this system being the best one, and altogether placing out of court the arrangement described as existing in the Merchants' Refrigerating Company. Mr. Stone said that he did not think that they could be successful without the fans. He placed a high value upon their use, and thought that where fruit and vegetables were concerned, the constant movement of air must have the best effect.

This establishment is also fitted with a large cold-air fan in the first floor, which they can put on to various chambers as they might desire, to freshen the atmosphere or to sweeten the chambers where one particular kind of article has been stored for a long period.

There seems to be a good deal to be said for the system, but the writer could not understand why the fans could not be used equally well in chambers entirely fitted all round with piping. These latter pipes would be, naturally, of much smaller

diameter and less liable to leakage, of which there appears to be a considerable quantity in all the chambers which were inspected. As an answer to this, Mr. Stone said that when space was a great object, the bunker system enabled them to stow more closely, and utilize more particularly every inch of space at their command.

The plant is run by three water-tube boilers, and three Pontifex-Henriques machines, built at Newark, and put in under the supervision of the Star Engineering Company, Consulting Engineers, of 258, Broadway, New York. This machine is very similar to the Isbell-Porter, but differs in the way of having various alterations in the fitment of valves. While cooling a full load the consumption of fuel is 15 tons, and the labour required to upkeep the above is three engineers, three firemen, and three cleaners.

Temperatures.—Meat, game, etc., are kept at 10°; butter, 27°; eggs, 31°; fish in barrels, 26°; dried and fresh fruits, from 34° to 36°; vegetables 38°; floral produce in cases, 37°.

With regard to the meat chambers, kept at a temperature of around about zero, the installation of piping placed within them is sufficient to ensure what is wanted without the assistance of fans.

Interview with Mr. C. E. Thurston, late Manager of the Earl Fruit Company, and at present one of the largest forwarding Fruit Agents in New York.

This gentleman says that he has been dealing for the last fifteen years with the growth and carrying of apples, oranges, pears, peaches, plums, cherries, and grapes.

Picking of the Fruit.—This, in his judgement, requires the greatest care, because it is necessary to distinguish between fruits which are for domestic purposes, and those which are for exportation. If for the former, then the fruit can be picked in more mature state, naturally, than if for the latter, where some long period must elapse before it is put in the market; but for whichever ultimate use the fruit is intended, Mr. Thurston is very strongly of opinion that successful delivery on to the market is only attained by watching this point in the closest possible manner. The fruit is always picked very early in the morning before the sun gains any strength at all, and it is gathered into shallow, long boxes, which have the sides perforated with holes, about $1\frac{1}{4}$ inches in diameter, and capable of containing about 20 lb. of fruit in two layers only, so as to prevent, as much as possible, the slightest bruising while in transit from the orchards to the packing houses. The boxes are brought to the shelter of the packing shed, where they remain stacked up out of the sun during the whole of the day, and are not packed until quite late in the evening when the temperature has fallen to the minimum. Mr. Thurston regards the cooling off of the fruit, prior to packing, as an absolute essential to successful delivery. He says that if the fruit is packed during a hot day, when it would naturally retain heat, no amount of after-refrigeration will

have the necessary perservative effect, because, although the outside of the fruit may be apparently cool, still, the inside having retained the heat, a process of decay is set up under refrigeration.

Packing Sheds.—These are practically open-air structures, having merely a thick roof to keep out sun and rain, and the sides left as open as possible so as to allow all the air to get at the fruit while it is being packed. The temperature of the packing rooms would be that, naturally, of the outside atmosphere, and none of them as far as Mr. Thurston has seen, or has ever heard of, are artificially cooled.

Temperature in which Fruit carries best.—Mr. Thurston has found that the most reliable temperature in which to carry fruit is 38°. This is the temperature which the fruit experts instruct the American Line to maintain, and during the five years he has been exporting to Covent Garden, the results have been excellent, and indeed, according to him, failure to deliver in splendid order has been almost entirely absent.

With regard to keeping this temperature on the rail cars during the hot months, there has been a difficulty under the present system of cooling with ice bunkers, and although the ends of the cars may have been kept from 36° to 38°, he is of opinion that in the centre it has been more like 45°. Notwithstanding this high jump, he has had to record but few mishaps, and thinks if he can always ensure an average temperature of 40° in the cars, and 38° in the steamers, but little of his fruit will suffer. Mr Thurston has not seen the necessity or value, as yet, of using fans in cold storage. He is an advocate for changing the air in the cars by opening the side doors and ventilators when he can do so in cool weather, more especially when oranges or hard pears are being dealt with; but the writer gathered that the points upon which Mr. Thurston laid the greatest stress were—first, the state of the fruit when it is picked, and secondly, the avoidance of heat during the process of packing and up to the time it is placed in the refrigerator cars. In order more readily to assist this, the fruit is always conveyed to, and loaded on, the cars during the small hours of the morning, and transferred from the cars to the ship at New York during the cool hours of the evening or night.

The Union-Castle Mail Steamship Company, Ltd.—to Capetown Agency.

With reference to the suggestions contained in your letter of October 21 and 28 in regard to placing fans in one or two steamers carrying grapes in the early part of the year, we have been very desirous to meet the wishes of Mr. Dicey and Mr. Pickstone, if at all possible, and with this view we have had a long consultation with Messrs. J. & E. Hall, Ltd., who are people who have carried out the refrigeration in the majority of steamers carrying fruit, and particularly that of the steamers to which Mr. Pickstone alluded and which he saw, namely,

those carrying bananas from Jamaica. We have discussed the whole subject with this firm and our superintendent engineer, and the result is just what we anticipated in our letter to you of October 1, when we pointed out that a confusion had arisen in the minds of Mr. Pickstone and Mr. Dicey in regard to two different systems of refrigeration. There is no system of refrigeration in which fans are placed in the chambers themselves. If fans were placed in our chambers, the result would be to destroy the present system of automatic circulation and cooling, and endanger the carrying in these chambers. We enclose a copy of a letter which Messrs. J. & E. Hall addressed to us on this subject after our interview, from which you will observe that they unhesitatingly condemn the possibility of fans in the chambers.

You will be interested to observe what they state in regard to the desirability of the fruit being cooled beforehand on shore, together with the other observations towards the latter end of their letter. As already mentioned, this firm has a wider experience than any other in the carriage of fruit in cool chambers from every part of the world. There is no higher authority on the subject. We are very desirous of assuring Messrs. Pickstone and Dicey that we are ready to do anything and everything which will contribute to the successful carriage of the fruit, and we therefore desire that you should send them a copy of this letter, as well as that of Messrs. J. & E. Hall.

As we have already pointed out, Mr. Molteno has given this question his very careful consideration, with an experience of what has taken place at both ends, and he has no doubt that the secret of the want of success in regard to the carriage of the grapes has been the fact that they have been exposed to high temperatures during and after picking and before they have been placed in the cool chamber, and that if the proper means are taken to obviate this, there would be the same success in carrying this fruit as with the other fruits.

We again mention the experience of Mr. W. H. Lategan, who, even without special refrigeration and by the adoption of precautions in regard to the hour of picking and mode of packing, has been universally successful in sending his fruit in the same chambers in which other fruit was carried badly.

We were very pleased to observe the tone of Mr. Hammersley-Heenan's letter in acknowledging receipt of a copy of our letter enclosing information gained at New York, because it evinces a great readiness to assist us in every way in this matter. The regulations which we have drawn up in regard to the mode of securing the passage of the cold air in our chambers by means of dunnage below and keeping airways throughout the mass in the direction of the current of the air, are all applicable to the stowage of the fruit in the cool chamber on shore, but in the latter the air spaces around the cases should all be increased so as to obviate any doubt of the cold air reaching the cases as soon as possible to get the first heat reduced.

Messrs. J. & E. Hall, Ltd.—to Union-Castle Mail Steamship Company, Ltd.

We have been considering, as you requested, the proposal to add fans to the refrigerated chambers on board your ships, wherein fruit is carried from the Cape, and where such chambers are at present cooled by means of brine pipes fixed on the sides and ends of the chambers. We understand that the proposal is based on the assumption that the fans will have the effect of ensuring greater uniformity throughout the chambers.

There are three systems by which fruit is carried in refrigerated chambers, viz. :—

(1) Cold air from a cool dry air machine is delivered direct to the chamber but with special precautions to prevent its coming in contact with the fruit until it has been tempered by mixing with the air already in the chamber. As this system does not apply with a CO_2 machine, it need not be further dealt with here.

(2) Brine grids are arranged on the sides and ends of the chamber with wooden diaphragms in front of them extending to within about 6 inches from the top and bottom of the chamber. The air cooled by contact with the cold pipes falls on account of its greater density and can only be replaced by air drawn in from the top of the chamber, consequently an active air current is set up ; the cold air passes along the floor battens under the cargo, rises through the cargo and returns through the top opening above the diaphragm to be re-cooled. This is the most perfect system of air circulation, as it is entirely automatic and continues without intermission, so long as the pipes are colder than the chamber. It is obvious, however, that the system is limited in its application by the size of the chamber, and for chambers over a certain width artificial circulation is necessary as explained in system 3.

(3) Air is cooled by being circulated by a fan over a nest of cold brine pipes arranged externally to the chamber and then delivered in large volumes to the chamber. This system is adopted in the case of very large chambers, such as the complete 'tween decks or holds of a vessel. It necessitates a very complete system of suction and delivery air trunks arranged with adjustable slides, and as these slides have to be regulated from time to time during the voyage as the thermometers may indicate, the trunks have to be of a size sufficient for a man to crawl along.

Your chambers are of small size, and without considering for the moment any question of *convenience* of one system over the other or loss of space due to air trunks, etc., we are satisfied that the system 2, which you have adopted, is the best from the point of view of the keeping of the fruit in good condition. For instance, supposing the fruit in one portion of the chamber is riper than in other parts, greater heat will be generated and a more energetic cooling action will be required at the point. By the mechanical air circulating system this will be attained by the regulation of the air slides, but the attendant

will only do this *after* he has observed the indication of greater generation of heat by the chamber thermometers. In chambers fitted as yours with system 2, the more energetic cooling action is automatically brought into play instantaneously by even so slight a rise as would hardly be observable on a thermometer.

The diaphragms in front of the grids prevent any radiation of excessive cold against the fruit, and we consider it is easier to keep an equable temperature without any excessive local variation by means of your system than with the mechanical air system.

The proposal which we understand has been made is to introduce into your chambers, fitted, as they are, with side grids and diaphragms, and working with the automatic air system, fans in order, we suppose, to circulate the air and ensure an even temperature throughout.

In the first place, a fan necessitates air suction and delivery trunks, without which the air cannot be distributed evenly throughout the chamber; such trunks must be large enough for a man to crawl along, as it is impossible to adjust air slides properly until after the cargo is in; then the air, either on the suction or delivery side of the fan, must be caused to pass over the cooling pipes, and it is not easy to see how this can be done without adopting system 3 in its entirety.

Supposing a fan were introduced without any special arrangements for passing the air over the cooling surfaces, the effect of the cold pipes in removing the excess of moisture from the air would be lost to a great extent, and we should expect the air to attain a more humid nature, which would not be so good for the preservation of the fruit. Of course, no circulation of air in the chamber can affect the gases given off by the fruit; these can only be got rid of by introducing fresh air from the atmosphere, which we think unnecessary, but which, if adopted, would necessitate an additional air-cooler in order to cool down the fresh incoming air to the temperature of the fruit chamber. Where this is not done, the fresh incoming air would not only warm the fruit which it impinges upon, but it would also introduce a considerable amount of moisture.

Furthermore, the introduction of a fan would quite upset the automatic movement of the air which now goes on and might consequently prove very detrimental. In short, either the automatic system or the mechanical system should be adopted, but not a combination of both, and we believe you will secure the best results by the automatic system which you have.

Of course any system depends for its success upon proper stowage of the cargo and the leaving of air spaces, and we understand this is a point to which you have given careful attention. It would also be of immense advantage if all fruit before stowing in bulk on board could be cooled beforehand in stores ashore, and we do not think that sufficient importance is attached to this. When a cargo of warm fruit is stored in a large bulk, it stands to reason that it must take considerably

longer for the heat to be got rid of and the fruit brought down to the temperature at which it ought to be carried, than if the fruit is exposed in a cold chamber ashore with considerable air spaces around the cases, and it is therefore obvious that fruit which has thus been cooled before shipment has a much better chance of being landed in this country in a good condition. Moreover, the material used for packing the fruit being a good non-conductor of heat further militates against the rapid cooling of the fruit and enables it to hold its heat longer than would otherwise be the case. It is advisable, therefore, that the minimum quantity of this material should be used -only what is just sufficient to prevent bruising. The adoption of cold storage ashore would probably also ensure the better inspection of the fruit and the rejection of over-ripe fruit, which no system of refrigeration can bring satisfactorily to this country.

CARRIAGE OF FRUIT FROM BARBADOS.

We publish also for general information the following correspondence, which has passed between the Imperial Commissioner of Agriculture for the West Indies and the Royal Mail Steam Packet Company, relative to the conveyance of fruit by the steamers of the company between the West Indies and the United Kingdom :—

Imperial Commissioner of Agriculture—to the Manager, Royal Mail Steam Packet Company.

Barbados,

December 15, 1903.

Sir,

On my return to Barbados from the United States by way of Jamaica, I found your letter of September 15 awaiting me.

I have been greatly interested to read what you say in regard to the different methods adopted for carrying fruit from the West Indies.

The special plan adopted for packing the Chinese banana (which is identical with the Canary banana) at Barbados is, we are convinced, the best in the interests of the planters here. We desire to establish a trade in this banana on entirely different lines from that adopted at Jamaica, by the United Fruit Company, and at Trinidad by the Symington Syndicate.

We propose to continue this form of packing as we believe it is calculated to yield the best results, provided we obtain suitable conditions on board the Royal Mail steamers. Under ordinary circumstances, we believe that an efficient system of ventilation by means of fans should be sufficient to enable this fruit to arrive in England in excellent condition. Of course, if the weather continues hot all the way, as happened in the case of the shipment by the 'Orinoco' in August last, this system may break down; but even then, if care be taken to stow the fruit with alleys all round and with a circulation of air beneath and above the fruit, the chances are that a large proportion of it will arrive in good condition.

In view of the great care now exercised in examining the fruit before it is shipped and in rejecting all crates in which the fruit is too ripe or the packing is imperfect, there should be very few instances in which any large proportion of the fruit is landed in bad condition. The tendency of the company, I notice, is, when fruit is landed in an unsatisfactory condition, to lay the blame on the selection and packing at this end; but this cannot possibly apply in the case of a whole consignment going wrong, as happened with the fruit shipped by the 'Tagus' on August 15 last. This fruit, as already pointed out in my letter by last mail, must have been subjected to very unfavourable conditions to have arrived in a 'rotten' condition.

I fully appreciate the nature of the difficulties to be solved by the Royal Mail Company in affording exactly the right conditions for the Barbados fruit by all their present steamers. The subject is a comparatively new one and it can only be adequately dealt with by careful and sympathetic treatment by all concerned. This Department is taking a keen interest in it and is prepared to assist the Royal Mail Company to the fullest extent.

In order to clear the way for a definite understanding in regard to the shipment of bananas from the West Indies, it is desirable to distinguish between the special requirements of Barbados, and the other islands: Barbados, at present at all events, does not require cold storage for its bananas. It will continue to pack them in crates, and all it requires is careful handling and thorough ventilation of the fruit chamber by means of fans sufficiently large to ensure a continuous current of air passing around the crates during the whole voyage.

All the other islands (including Trinidad, where the bananas are shipped loose without crates) will require, in my opinion, a system that provides cool air in large volume to be circulated through the fruit chamber. The same air should be continuously passed through the chamber and returned to the refrigerators, where, on each occasion, it would be entirely deprived of its moisture. The best and, in fact, the only system that has proved satisfactory for this purpose is the Hall system. No doubt you are fully acquainted with this. The City Office is 23, St. Swithin's Lane, E.C.

I can understand that, until there is a visible supply of bananas and other fruit, the Royal Mail Company cannot adopt this system in all their ships. On the other hand, until something is done to give confidence to the planters, they will not feel justified in extending the cultivation of fruit on an extensive scale, as in Jamaica. It would be well, therefore, if the company were to state exactly what they are prepared to do to develop a fruit trade, and publish their views as early as possible.

I have long realized, that with the best intentions in the world, the present mail ships are not suitable for conveying fruit. The space available is too small, and the amount of freight possible to be earned by them will

not justify the installation of a cold-storage system on the scale necessary to meet requirements. What are necessary are ships specially fitted for the fruit trade and capable of steaming at least 15 knots per hour. If these cannot be provided, it will be impossible for the Royal Mail Company to look forward to any considerable development of the fruit trade between these islands and the United Kingdom.

What has already been attempted by the Royal Mail Company has, however, attracted a good deal of attention. The interest created by the visits of Mr. Symington, and the addresses delivered by him, in which he refers to the support given to him by the Royal Mail Company, have raised expectations that the company cannot now ignore. In fact, they are pledged to afford Mr. Symington's scheme the fullest measure of support, and it is difficult to understand how this can be done unless ships are specially fitted for dealing with the fruit now being grown at Trinidad and Tobago as the result of the understanding between the Royal Mail Company and Mr. Symington.

I have discussed some of the points referred to in this letter with Captain Constantine, at Jamaica, and with Captain Owen, at Barbados. The latter officer has very carefully gone into details with me, and I am satisfied that the Royal Mail Company cannot do better than be guided by his wide experience and his intimate knowledge of the circumstances of these colonies.

I have, etc.,

(Sgd.) D. MORRIS.

The Chairman, Royal Mail Steam Packet Company—to the Imperial Commissioner of Agriculture for the West Indies.

18, Moorgate Street,
London, E.C.,
January 19, 1904.

Sir,

I have to acknowledge the receipt of your letter of the 15th. ultimo (No. 4,502).

From my previous communications you are aware that the question of the conveyance of fruit from the West Indies has been having my close personal attention.

Chinese Bananas from Barbados.—I note that your desire is to establish a trade in the Chinese banana from Barbados on entirely different lines from those adopted at Jamaica by the United Fruit Company of U.S.A., or at Trinidad by the Symington Syndicate, and that, in your opinion, a system of ventilation by means of fans is sufficient to enable the Chinese banana, when packed in crates, to arrive in England in good condition.

I also note that cold storage is not required for bananas from Barbados, provided the fruit chamber is thoroughly ventilated by fans sufficiently large to ensure a current of air through the compartment.

Ordinary Bananas and other Fruits.—The result of my recent investigations has caused me to form an opinion coincident with your own, as to the best system of fitting steamers for the carriage of fruit, and I have now arranged to fit the system recommended by you in the 'Tagus' and 'Trent,' in place of the existing system. The same air will then be continually passed through the chambers and returned to the refrigerators, when, on each occasion, it will be deprived of any moisture. When this work is carried out, and we have had time to ascertain by practical experience if the results are satisfactory, my company will take into consideration fitting a similar system in the other mail steamers.

The expense of making the change will be considerable, but it will be evidence of our desire of doing everything possible to meet your wishes, and it is a satisfaction to me to know that you fully appreciate the difficulties which we have had to solve in affording exactly the right conditions for the carriage of different classes of fruit in our mail steamers.

I agree with you that it is only by careful and sympathetic treatment by all concerned that a satisfactory result is possible.

The information contained in your recent letters has been of the greatest assistance to us all.

I agree with the view you express that, if the fruit trade develops, the space available in the mail steamers would be too small to meet the possible requirements of the fruit trade.

I note that, in your opinion, it will be necessary, if the trade develops, to have ships specially fitted for the fruit trade, capable of steaming at least 15 knots per hour, and that, unless such vessels are provided, you consider that it will be impossible to look forward to any considerable development in the fruit trade between the West India Islands and the United Kingdom. I am communicating with the Colonial Office, to ascertain if the Government would entertain granting a subsidy for placing such vessels on the service, as such fast fruit ships would be very expensive to run.

It will, of course, be apparent to you that this new trade will require nursing of this kind, as, apart from a subsidy in some form, it could hardly be expected to prosper.

As the result of further experience, I hope it may be found possible to carry fruit to England in good order in steamers of more moderate speed.

I repeat that my company is desirous of doing everything possible to assist in the development of this trade between the West India Islands and the United Kingdom: and in thanking you for the very valuable suggestions submitted in your communication now under acknowledgement, I have to state that I shall be only too pleased to take into consideration any

further proposals you have to offer, recognizing as I do the very important part you are taking to place the industry on a better footing.

I have, etc.,

(Sgd.) OWEN PHILLIPS,
Chairman.

The Royal Mail Steam Packet Company—to Professor J. P. d'Albuquerque.

Barbados,
July 27, 1904.

Dear Sir,

Herewith I beg to hand you an extract of a letter received by me from the Head Office of my company in London with reference to some remarks made (as to the condition of fruit at time of shipment) by Messrs. J. & E. Hall, Ltd., who have just completed the fittings of the 'Tagus' and 'Trent' for the cool transport of fruit.

I shall be glad if you will make known, through your Department, the necessity for exercising the greatest care in the picking of the fruit so that it may be in the proper condition at time of shipment.

Thanking you in anticipation for what you may do in connexion with this matter, which is a very important one to shippers,

I am, etc.,

(Sgd.) W. F. SELLERS,
for Royal Mail Steam Packet Company.

Extract of letter from London, dated June 23, 1904.

Condition of Fruit on Shipment.—Will you be good enough to call the attention of the representative of Sir D. Morris in the West Indies and that of fruit shippers generally to the following remarks made to us by Messrs. J. & E. Hall, who have just completed the fitting of the 'Tagus' and 'Trent' for the cool transport of fruit:—

'The success of the fruit-carrying department will largely depend upon the condition in which the fruit is stowed and upon the handling of the plant before and after loading. If the fruit is cut too "full", no refrigerating power will carry it, once it has reached a certain degree of ripeness. It is found necessary on large fruit-carrying steamers to watch very closely the loading, and the different degrees of ripeness of fruit are very difficult to determine by any but experts. We wish to

draw attention to the importance of this aspect of the question, as we notice that even with all precautions on the part of shipowners bananas are very often put on board in a state which is very prejudicial to their safe carriage and to obtaining a good market price at this end.'

As above stated, all efforts in regard to refrigeration will be neutralized and rendered valueless, unless care be taken in the selection of fruit in a suitable condition for standing the voyage between the West Indies and Plymouth.

A BACTERIAL ROT OF ONIONS.

During the past season, planters of onions in Barbados have been considerably troubled by a rot which attacked one or more of the inner scales of the bulb, being generally noticed after the onions had been gathered and stored; the outer scales were usually sound. It will be seen that the only way of preventing the disease is to keep the onions as dry as possible, both while growing and after; the use of raw farmyard or pen manure is to be avoided.

The following extracts, taken from a letter from the Hon. Forster M. Alleyne to the Commissioner of Agriculture, will describe the disease:—

'I have no reason to be dissatisfied with the amount produced per acre on most of our estates; but the fact remains that dry them, cure them, plait them up, hang them up, as we will, they sooner or later rot in the centre.

'The onions are of good size and beautiful in flavour, but they will not keep; while those imported from Bermuda are perfectly sound. What is the point in which we fail?

'It is most disappointing to find that one has thousands of pounds of onions on hand which no one will buy because the centre is practically rotten. Has the seed anything to do with it? Did we plant at the wrong time? Were the onions treated wrongly? When we got a return of 4,000 lb. per acre, as we did at the Ridge, it is difficult to think that there is much wrong in the cultivation. Was the failure in any way connected with the season?

'I speak on behalf of seven estates where I have planted them, and all the managers have had the same experience.'

On examination of the diseased bulbs it was found that the affected scales were swarming with motile bacteria. No fungus hyphae were found in the tissues. It seemed probable that the bacteria were the immediate cause of the rot and that their growth was favoured by the exceptionally wet season. In most cases it appeared that the rot started at the 'neck' of the bulbs.

The following extracts from a letter from the Commissioner of Agriculture to the Hon. Forster M. Alleyne will show that inquiry was made of a number of persons who had experience in growing onions :—

'I am communicating on the subject with planters at Antigua, Montserrat, and other parts of the West Indies with a view to obtaining the results of their experiences, and what steps, if any, have been taken by them to avoid loss from "rot." I am not without hope that, by making a careful inquiry into the circumstances, we may be able to arrive at some means of avoiding loss due to this cause in future.

'The seed planted in the West Indies is exactly similar to that planted in Bermuda. It is the very best obtainable and is guaranteed to be from healthy plants.

'It is not improbable that the exceptional seasons experienced at Barbados during the last twelve months may have something to do with it.'

The following are extracts from their replies :—

Mr. J. R. Bovell, F.L.S., F.C.S., Agricultural Superintendent, Barbados :—

'In reply, I regret to say that the onions grown this year have in a great many instances developed this rot, and for some time I have been looking up the subject and thinking what could have caused this decay, but up to the present time I have come across no reference in any literature I have on the subject. One grower tells me that where his onions had thrips they rotted in the centre, and where there were no thrips there was no decay. I know that some of Mr. Alleyne's onions both at Ridge and Buttals had the thrips badly, as I saw them.

'The unusually heavy rainfall during last December, January and February, when the onions were growing and ripening, may have had something to do with this rot, as also perhaps the fact that, in nearly every instance, the land in which the onions were grown had been treated with raw farmyard manure.'

The Hon. Francis Watts, D.Sc., F.I.C., F.C.S., Superintendent of Agriculture for the Leeward Islands :—

'A similar rotting was observed in Antigua at times, but I do not learn that it has been regarded as serious.

'Most persons think that it is in some way connected with an excess of moisture, which excess may manifest itself in several ways.

'If the rotting takes place in the field it is thought that it may be due to the excess of moisture which comes from a heavy retentive soil, from too much rain, or from over manuring and the production of soft watery plants.

'Where the rotting is observed after gathering, it is suggested that it is due to the excess of moisture in imperfectly ripened bulbs, or from a deficiency of drying and curing room ; upon this latter a good deal of stress is generally laid.

'At present no planter in Antigua has suggested to me that it is a specific disease, but this possibility should be kept in mind in making any further inquiries or investigations.'

Mr. W. N. Sands, Agricultural Superintendent, St. Vincent:—

'This is a fairly common complaint, even in Antigua, especially if the season of harvesting is a showery or wet one. One of the most successful growers used often to pull his onions, if the bulbs were full and ripe looking, even before the tops had dried down, and he was of opinion that it was a mistake to keep the onions too long on the land after the bulbs were apparently full ripe. He then carefully dried them in sheds, with the tops on, and when quite dry cut off the tops about 1½ inches from the crown.

'The Bermuda onion when grown in the tropics will not keep, and should be shipped as soon as dried. I refer to the white variety. The red variety keeps for a much longer time.

'The rot, I feel sure, is due chiefly to unfavourable climatic conditions rather than any error of culture or drying.

'I have no doubt but that the Mycologist will find out the fungus or bacterium causing the decay, and that a moist condition of the soil will be found to favour its growth.'

Mr. A. J. Jordan, Curator, Botanic Station, Montserrat:—

'I have made inquiries but have not found that there has been much loss through a disease attacking the hearts of the onions.

'One gentleman told me that he had found one dish of onions served at his dinner table with the hearts of the onions rotten, and I noticed one bulb similarly affected.

'The isolation of the cases gives colour to the theory of bad curing.'

Mr. T. Greiner, author of the *New Onion Culture*, La Salle, New York:—

'I have given some attention to the matter of the onion rot described by Mr. Forster M. Alleyne in his letter to you of April 27. This rot may be the 'Bacterial Rot' recently made a subject of investigation by the New York State Experiment Station at Geneva, N. Y. It often attacks one or more of the inner scales of the onion, and against it I know of only one means of prevention, namely, to keep the onions as dry as possible, both in the field and in storage.'

The rot in New York, mentioned by Mr. Greiner, is dealt with in *Bulletin* No. 164 of the New York Agricultural Experiment Station, by Mr. F. C. Stewart, M.S., published December 1899. As the Barbados disease would appear to be very similar to, if not identical with, that observed in New York, the following extracts are published from this bulletin:—

In the autumn of 1898 the report came to the Experiment Station that the onions in Orange County, N. Y., were rotting badly. Upon investigation it was found that in nearly all of the fields in this great onion-growing district there was a considerable amount of rot. In many cases from one-third to

one-half of the crop had to be rejected on account of it, and the remainder was not readily saleable because news of the rot had reached New York City produce dealers who were accordingly suspicious of all onions coming from Orange County. The same rot was also common in the onion fields of Madison County, but the losses from it were not nearly so great as in Orange County.

The rot was of two kinds: (1) One which starts at the bottom of the onion, and (2) one which starts at the top or 'neck'. The latter kind of rot was much the more common, constituting perhaps 80 per cent. of the total amount of rot. Where the rot had started at the top, the bulbs were frequently sound in appearance but rotten within. Oftentimes it was difficult to determine, before cutting, whether or not a bulb was rotten. In sorting, the customary test for soundness was to press down with the thumbs close about the 'neck' of the onion. If it was hard, the bulb was sound; but if soft, it was usually rotten inside. Onion growers speak of such onions as being 'weak in the neck'. Upon cutting open the affected bulbs it was generally found that two or three of the outer scales were perfectly sound while the remainder of the bulb was a rotten mass. Frequently a single scale would be entirely rotten from top to bottom and clear around the bulb, while the remaining scales upon both sides of it were perfectly sound. Such specimens cut crosswise showed the rotten part in the form of a ring. Again, a perfectly sound scale would be found between two rotten ones. The rot appears never to spread from one scale to another laterally, and this peculiarity furnishes the most reliable means for the identification of this rot. The organism causing it is unable to pass through the uninjured epidermis of the scale. The passage from one fleshy layer to another is effected at the base of the bulb, where they unite. Upon reaching the base of the scale in which it is working the rot commonly stops, and this accounts for the large number of cases in which one or two scales are rotten while the remainder of the bulb continues sound. Under certain conditions the rot does not stop at the base but works its way into the bases of other scales, which it then follows upward, destroying the whole bulb.

When the rot is confined to the outermost fleshy scale, as is frequently the case, the affected bulbs are called 'slippery onions'. Some of these are to be found in any season, but they are rarely so abundant as to cause material loss.

Microscopic examination of the rotten tissue shows entire absence of fungi, but there are swarms of a medium-sized, motile bacillus, which is without doubt the immediate cause of the rot.

Among stored onions kept reasonably dry the rot progresses very slowly, but wet onions rot rapidly, especially if the temperature is high.

All the evidence obtainable goes to show that this bacterial rot is not new, but that it is an old enemy, which found unusually favourable conditions for its development in some peculiarity of the weather during the season of 1898.

The weather records published by the New York State

Weather Bureau show that the rainfall in Orange County was excessive and the temperature high from the middle of July to the close of August 1898. At Middleton, which is on the edge of the onion district, the dates upon which rain fell during this period were as follows:—

Rainfall at Middleton, N.Y., July 18 to August 26, 1898.

Date.		Inches.	Date.		Inches.
July	18	·31	August	11	·80
,,	19	·51	,,	12	·08
,,	20	·90	,,	16	·28
,,	21	1·85	,,	17	1·31
,,	26	1·04	,,	19	·41
,,	28	·09	,,	23	3·08
,,	30	1·09	,,	24	·52
August	1	1·48	,,	26	·52
,,	4	1·15			
			Total	...	15·42

In forty days 15·42 inches of rain fell, and it was so evenly distributed over the period that the ground was almost constantly wet. The onion fields, being on a low level, were frequently inundated. In some cases, whole fields were covered by the water for a period of from twelve to thirty-six hours. It is not strange that the onions rotted.

The important rôle which water plays in this rot is shown by the behaviour of laboratory cultures. Sound onions were cut open, placed in a moist chamber, and inoculated upon the cut surface with bits of rotten onion. Sound onions in a moist chamber were bored to the centre with an awl and bits of rotten onion introduced into the wounds. At the end of a week there were no signs of rot. This experiment was repeated several times and always with the same result—the onions refused to rot. During these experiments the temperature of the room varied from 21° to 26° C. (70° to 79° F.).

Finally, sound onions inoculated externally with bits of rotten tissue were immersed in sterilized water and placed in an incubator kept at a temperature of 36° C. (97° F.). Other sound onions were treated in the same way except that they were not inoculated. Still others were inoculated by boring to the centre and introducing rotten tissue. These latter were then put into the incubator with the others, but not immersed in water. At the end of six days all of the onions immersed in water were rotten, including checks; while those which had been inoculated, but kept dry, were still perfectly sound.

These experiments indicate that one important point in the prevention of this rot is to keep the onions dry. In practice this is to be accomplished by protecting stored onions from rain and by draining the fields so that water will not stand upon them for any length of time.

Since the above was written some observations have been made upon the crop of 1899. The season of 1899 was unusually dry in Orange County, and yet there were a good many 'slippery' onions in some fields. In looking over the onion fields it was observed that some were almost entirely free from

weeds while others were thickly overgrown with them. It was in the latter kind of fields that the 'slippery' onions occurred. The explanation of this appears to be that the weeds kept the onions wet by retaining the dew and some light showers which fell just before harvest time, thereby furnishing favourable conditions for the rot. Clean cultivation will have a tendency to reduce the amount of rot.

THE CULTURE OF THE DATE PALM.

The date palm (*Phoenix dactilifera*) is cultivated principally in Northern Africa and in the countries bordering on the Persian Gulf. Its tall, straight trunk, covered with the scars of fallen leaf-stalks, and surmounted with a tuft of feathery leaves attains a great height—often of over 80 feet. It has the male and female flowers on separate individuals, and in its natural state the female flowers are pollinated by the wind. Each female tree produces from six to twenty flower clusters. each of which gives rise to a bunch of dates. The trees live to a great age and have been known to produce good crops up to 200 years of age. At the base of the stem a number of suckers arise, and by these offshoots the tree should be propagated, since the date palm is very liable to variation.

The average exports of dates from the Persian Gulf region for the five years ended 1902 amounted, according to figures contained in the *Consular Report* on the trade of the Persian Gulf for the year 1903, to 167,301 cwt.

As will be seen from the following pages, many attempts, some attended with considerable success, have been made to introduce the cultivation of the date palm into different parts of the world and to establish a date industry. Up to the present, so far as we know, the only place out of Africa and the Persian Gulf region, in which real success has been achieved, is in the island of St. Helena. It appears likely, however, that good results will be obtained in certain districts of the south-west of the United States.

In the following short account of the culture of the date palm free use has been made of three publications of the United States Department of Agriculture, viz., a paper in the *Yearbook* for 1900, entitled 'The Date Palm and its Culture,' and *Bulletin* No. 53 of the Bureau of Plant Industry, 'The Date Palm and its utilization in the south-western States', both by Mr. Walter T. Swingle; and *Bulletin* No. 54 of the Bureau of Plant Industry, 'Persian Gulf Dates and their introduction into America,' by Mr. David G. Fairchild.

CLIMATIC REQUIREMENTS OF THE DATE PALM.

The date palm requires, above everything else, a plentiful supply of water for its roots, and a hot, dry atmosphere in which to mature its fruits. There are many districts, including parts of the West Indies, where the tree has grown well, but where it is doubtful if good fruits will be obtained on account of the humidity of the atmosphere. On the other hand, such climatic conditions as are required by the date palm are known to exist in parts of the United States, and it is upon this fact that the hopes for its successful introduction as a new industry in that country are based.

It would appear advisable to state clearly the requirements of the date as to climate and water supply.

Heat.—One of the principal requirements of the date is a high temperature, especially when it is maturing its fruit. In the winter they are able to withstand a fair amount of cold; but for the ripening of the fruit a high temperature is absolutely necessary. Swingle states: 'There is little hope of growing even early sorts unless the mean temperature in the shade goes above 80° F. for at least one month in summer, and the mean temperature of the fruiting season, from May to October, is above 70° F. It is, further, fairly certain that during the months when the fruit is developing, viz., May to October, inclusive, the mean temperature must be about 75° F., and during June, July, and August above 80° F., if moderately late varieties of dates are to be brought to maturity. In regions where late varieties of dates come to maturity, the mean temperature for June, July, and August must be 90° F. or thereabouts.

Dry atmosphere.—In this case, again, while the date palm grows fairly well in a moist climate, the fruit matures properly only in a dry atmosphere. Consequently, dates are grown most successfully in the hottest and driest regions.

Water supply.—Although the date delights in a dry, hot climate, it requires a constant, though not particularly abundant, supply of water at its roots. The subject of irrigation is therefore one of primary importance to the date grower.

PLANTING AND CULTIVATION.

The Arabs of Mesopotamia plant only suckers: these are seldom over 6 feet long and generally with few roots. They are planted with the growing bud only 2 or 3 inches above the surface of the soil, and for the first month are watered every four days, and later at longer intervals as the season may demand.

The French colonists give much more attention to the careful planting of dates. They plant in regular rows, the arrangement depending, as a rule, on some properly conceived system of irrigation. It is held by them that the palms should be placed at distances of 30 feet, and the intervening spaces are usually occupied by garden crops

It is found in the Sahara that one male tree will provide sufficient pollen for about 100 female trees, and the male and female trees are accordingly planted in this proportion.

Little has been done in the way of working out the manurial requirements of the date palm. The Arabs use what manure they can obtain from their camels and goats. On the larger plantations it has been found impossible to obtain a sufficiently large supply of farmyard manure. There can be no doubt that a proper system of green manuring, with such leguminous plants as alfalfa, horse bean, cow pea, and others, would be a great advantage. Neither in Africa nor on the Persian Gulf does any such system appear to be known.

As subsidiary crops between the palms, in addition to garden produce, cereals are frequently grown, but the yield is rarely good; grape vines appear also to thrive well and produce good fruit. Many fruit trees, including olives, seem to appreciate the shade afforded by the date palms.

IRRIGATION.

In the Sahara, irrigation is practised by means of trenches, where no crops are grown under the palms. These are excavated alongside of the trees and occasionally filled with water. Where barley or alfalfa is grown, the land is divided up into small beds, from 10 to 30 feet in diameter, which are surrounded by a raised rim. The bed can then be flooded. On account of the alkalinity of the soil, it is found especially necessary to provide a good drainage system.

Mr. Fairchild gives the following account of the method of irrigation practised at Dassorah :—

'The method of planting is determined by the irrigation ditches, which are large (often 3 feet by 3 feet) and cut the ground up into small rectangular peninsulas, 10 to 15 feet by 20 to 30 feet in size. On each peninsula two, or sometimes three, palms are set. Often the peninsulas are much larger and hold from four to five or even as high as ten palms. The size of these peninsulas depends somewhat on the permeability of the soil and the height to which the irrigation water rises in the ditches. On an average 100 palms are planted to a "djerib," which unit of measure is a trifle less than an acre.

'In order to prevent the waters receding too quickly from the canals when the tide falls, dams of mud are built, and pipes, or the hollow trunks of palms, are run through them, which permit the water forced into the canals by the rising tide to flow away slowly. The length of time during which the canals are filled with water is more or less under the control of the proprietor, and as the supply is practically unlimited, no tax of any kind is paid, nor is any regulation necessary regarding its use.

'In short, the Bassorah date grower has only to see that his ditches are kept in order, which is an easy matter where the soil is as pure adobe as the clay of a brick-yard, and the backwater of the river will fill and empty them twice every twenty-four hours. The conditions of this form of irrigation,

which might be called a tidal one, are quite ideal and so far as known are found on such a scale nowhere else in the world.'

POLLINATION OF THE DATE PALM.

Male and female plants are produced in about equal numbers. As has been stated, date palms are pollinated in the wild state by wind, but where the trees are pollinated artificially, only one male tree is required for every 100 female.

'The male flower cluster of the date consists of a stalk bearing a considerable number of short twigs to which the flowers are attached, the whole contained in a sheath, at first entirely closed, but which finally ruptures, disclosing the flowers. The Arabs cut the male flower clusters from the trees shortly before the flowers have fully opened. The separate twigs to which are attached the male flowers are from 4 to 6 inches long, and bear probably from twenty to fifty male flowers, each containing six anthers full of pollen. One of such twigs suffices to pollinate a whole female flower cluster, and to bring about the development of a bunch of dates.

'The female flowers, like the male, are borne inside of sheaths which are at first entirely closed. Finally the sheath is split open by the growth of the flowers within, and at this stage pollination is accomplished. The two tips of the cracked-open sheath are separated, and the cluster of female flowers pulled out. A twig of male flowers is then inserted into the cluster of female flowers and tied in place by a bit of palm leaf or with a string. This completes the operation of pollination.

'The fruit cluster soon begins to grow rapidly, and in a few weeks the piece of palm fibre or thread with which the male flowers are held in place, is broken by the pressure of the growing fruit cluster.'*

YIELD, ETC.

The age at which date palms commence to bear depends very much upon the climate, the fertility of the soil, and the water supply. In Arizona, United States, it is stated by Swingle, trees have been known to bear within four years of the planting of the seed. It is, however, usually considered that trees do not yield paying quantities of fruit till they are from six to eight years old.

In regard to the bearing of the date palm, Swingle writes: 'When date cultivation is practised scientifically, practically no seedlings are grown, but instead orchards are started by planting fairly large offshoots, which soon strike root, and which often bear abundantly four or five years after being transplanted. However, in the large plantations made in Algeria by the French, it is not considered advisable to allow the palms grown from offshoots to bear fruit until six years after they are transplanted, and the trees are not in full bearing until ten or eleven years after they are planted.

* *Bulletin* No. 53, Bureau of Plant Industry, United States Department of Agriculture, pp. 26-7.

'They continue bearing from this age, if well cared for, until they are 100 years or more old, a good tree producing an average of from 100 lb. to 200 lb. of fruit a year, although some trees have been known to produce as much as 400 lb. or 600 lb., when grown in rich soil and abundantly irrigated.'

DATE CULTURE IN THE UNITED STATES.

Efforts have been made to establish a date-growing industry in various districts of the United States. There are portions of Nevada, California, and Arizona, where it is thought the date palm will thrive. In 1898, efforts were made to secure suckers of the best kinds of dates from Algeria. With these was started a special date garden in conjunction with the Arizona Agricultural Experiment Station, where a very large number of varieties of dates has been gathered together, and an attempt is being made to establish the cultivation of the date in some of the irrigable areas of the district.

In concluding his article, in the *Yearbook* for 1900, Swingle says :—

'It has been shown that there is good ground for the hope that enough dates to supply our markets may be produced within our boundaries, thus retaining in this country nearly half a million dollars now paid annually for foreign dates. It is even possible that a still larger trade may be built up by producing the choicer varieties suitable for serving as table fruit, such as the "Deglet Noor," now so rare on our markets and so costly as to preclude its being sold in any large quantities.

'The date palm has been shown to be adapted to special soil conditions occurring only in a few areas of limited extent in the South-west. It requires a long, extremely dry and hot summer in order to mature its fruits properly, yet the roots demand a constant supply of water. It is unable to endure severe cold in winter, although more hardy than the orange tree. It is pre-eminently suited for culture in irrigated areas in desert regions, and, fortunately, is able to endure without injury large quantities of alkali in the soil and in the water used for irrigating, conditions often occurring in desert regions, and which prevent the growth of most cultivated plants. There are many places in Arizona and California where the culture of the date can be undertaken with good hope of success. Marketable dates of good quality have already been produced in considerable quantities in the Salt River Valley, Arizona, and excellent fresh dates ripen every year at Winters, in northern California.

'The Department of Agriculture and the University of Arizona have undertaken in co-operation the establishment and maintenance of a special date garden at Tempe, in the Salt River Valley, Arizona, and in 1899-1900 about 420 young palms, comprising about twenty-seven of the best known varieties, including the famous "Deglet Noor," were imported by the Department from the best date regions of the western

Sahara and sent to this garden, where they are now growing. Some three dozen plants of the "Rhars," one of the best early dates for drying, were distributed at the same time in California in co-operation with the University of California.'

Three years later, in *Bulletin* No. 53, Swingle writes :—

'The collection of varieties at the Co-operative Date Garden at Tempe is by far the most complete in the world, since it comprises the best known varieties from the Algerian Sahara, from Egypt, and from the regions about Bassorah and Maskat, where most of the dates imported into America are produced, as well as a large collection of varieties from the Pangh Ghur region in Baluchistan. Together with the seedlings that have originated in the valley and the sorts growing at the experiment station farm at Phœnix, there are something over ninety named varieties now on trial in the Salt River Valley. It is very probable that some of these will prove to be adapted for profitable culture in this valley, even if the Deglet Noor can not mature.

'There are several seedling dates that have originated in the Salt River Valley in Arizona, which promise to be valuable.

'In addition, there are several other seedling varieties of considerable value which have already fruited in central Arizona, some of which may prove adapted to culture on a large scale.

'Two of the varieties introduced from Egypt by the Department of Agriculture in 1890 have been fruiting for some time at Phœnix, Arizona. In 1900, one of the sorts, the Amreeyah, bore over 300 ℔., while another, the Seewah, bore over 200 ℔. These dates were packed in $\frac{1}{2}$-℔. boxes, and Professor A. J. McClatchie writes that they sold readily for 20c. a box wholesale and 25c. retail, and there was a demand in the local market for ten times the quantity that could be furnished. The Seewah, in particular, is a very promising date for culture in the Salt River Valley, in Professor McClatchie's opinion, as it is fairly early and of excellent quality.

'The choicest date that reaches America and Europe, the famous Deglet Noor of the Algerian and Tunisian Sahara, is very sweet, of exquisite flavour, and is adapted to serve as a dessert fruit; it sells for more than Smyrna figs, being the most expensive dried fruit on our markets. The demand for these dates during the holidays is nevertheless greater than the supply, and if they could be sold somewhat cheaper, the consumption of this fruit would be enormous.

'The Salton Basin or Colorado Desert, in south-eastern California, recently put under irrigation, has a hotter and drier summer climate than the Algerian and Tunisian Sahara, where the best grades of Deglet Noor dates are grown, and is, indeed, better adapted to the culture of this fruit, since not only is the climate more favourable but the soils are richer, and the irrigation water is of better quality.

'The date palm will prove of equal value on the more alkaline areas of other arid regions in the south-western States

where the winters are warm enough to permit it to grow. Most regions do not have sufficient summer heat to mature the Deglet Noor date, and other sorts which ripen earlier must be planted.

'It is very probable that the culture of the best second-class dates, suitable for employment in confectionery and for household uses, will prove a profitable industry in the Salt River Valley, Arizona, and it is possible that the Deglet Noor variety may mature there.'

DATE CULTURE IN THE WEST INDIES.

From the following notes it will be seen that attempts have been made to grow dates in several of the West India Islands.

In Antigua the results were, at one time at any rate, fairly satisfactory, and it is likely that with care and attention a small date-growing industry might be established.

We record also the efforts that have been made in Trinidad and Jamaica. While the palms have undoubtedly made satisfactory growth, it is as yet too early to form a definite opinion as to the prospects of establishing an industry.

Date palms have also been planted at Grenada and Tobago and have made good growth.

It is understood that rat-bats are very destructive to dates in these islands and are likely to prove a serious pest. A fungoid pest has also attacked dates in Antigua, Trinidad, and Jamaica. An account of this pest will be found on p. 148.

ANTIGUA.

The following extract from a report dated November 12, 1895, by Mr. A. G. Tillson, then Curator of the Botanic Station at Antigua, which was published in the *Kew Bulletin*, 1896, p. 26, gives an interesting account of the progress of an experiment in date palm cultivation at Copse Cross Station, near English Harbour. It will be seen that in this case trees fruited when only four and a half years old : this is unusually early, as it is very rare for fruiting to take place under five years :—

'In March 1891, I received from Kew a case of selected dates including the famous Tafilat variety.

'From the seed received I raised about 5,000 plants which were offered for sale in the Antigua *Standard*. Date growing being a new and untried industry and long in producing a return, the plants were not taken up.

'Plants were put out at the various stations, others sent to the Botanic Stations of Dominica, St. Kitt's-Nevis, and Montserrat, and some, in exchange, to the Grenada Botanic Station.

'It affords me much pleasure to report that at Copse Cross there are now eighty-six established date trees, three of which fruited during August of this year, being only four and a half years old.

'The English Harbour district seems very favourable to date culture.

'The following notes from Haldane's *Sub-tropical Cultivation and Climates* show the value of date cultivations, and the fine growth and early fruiting at Copse Cross are an index of what may be expected under local conditions :—

'"The yield of a tree in full bearing is from 100 ℔. to 200 ℔. per annum, but as much as 400 ℔. have been got from a single tree.

'"The tree generally produces eight to ten bunches of fruit, and the produce of a hectare ($2\frac{1}{2}$ acres) of land under this cultivation is about 14,400 ℔. of dates.

'"The value of dates in England is—Tafilat, 70*s.* to 84*s.* per cwt.; Egyptian, 28*s.* to 45*s.*; Bussore, 13*s.* to 21*s.* The trees live to a great age and produce fruit till 200 years old."'

Reporting to the Imperial Commissioner of Agriculture on a visit to this plantation in August 1902, Mr. W. N. Sands, at that time Curator of the Botanic Station, stated that there were then only twenty-four trees, the rest having died out or been destroyed.

Owing to neglect the trees were badly attacked by the fungus *Graphiola phoenicis*, and none of the trees were fruiting, although the native date was fruiting at the time.

The largest plants were then about 12 feet high, the rest varying from 6 feet upwards.

TRINIDAD.

In his annual report for the year ending March 31, 1903, Mr. J. H. Hart, Superintendent of the Royal Botanic Gardens, Trinidad, makes the following reference to date growing :—

'Plants of the date palm grown from seed have for many years fruited annually in these gardens, but though sweet and edible when ripe, the size was too small to be of saleable value.

'Some four years since, a suggestion was made to import stock propagated from suckers from trees known to produce high-class fruit, and after considerable delay a set of forty plants has been received from Algeria in good condition. The majority of these have been planted out and are making good progress. Three of the number were sent to the Tobago station with the approval of the Government.

'It will, of course, be some years before the results of this importation can be seen, but from the condition and health maintained by the old seedling kinds, it is believed there is nothing to hinder the production of good fruit, now that the right class of plant has been obtained. That they differ from the seedling kinds is evident by the fact that they have been raised from suckers arising from the base of the fruiting trees

while, except in a single instance, none of our seedling trees have ever produced suckers, and the tree showing this character actually produces the best fruit of any of its class. It is also evident that the Algerian trees will readily lend themselves to further propagation, as many of them already show signs of giving off a good supply of suckers.'

Again, in his report for the year 1903-4, Mr. Hart states:

'The consignment of date palms received from Algeria has nearly all been planted out in permanent positions, at St. Clair, St. Ann's, and two or three at the Tobago Station.

'A leaf fungus* was found infesting the plants the first season after planting, but this seems to be gradually disappearing as the plants become established.

'As these plants have been raised from suckers taken from trees which are known to produce a fine class of fruit, it is hoped that the importation may successfully accomplish the end in view, which is the production of a good-sized dessert fruit in the West Indies. It has been stated that good fruit cannot be produced on account of the climate not being suitable. As a matter of fact, the true date palm has regularly produced fruit in the lands of the Botanical Department for many years past, but not of a size to render it of use for the table. Hitherto the plants have all been seedlings, and more could not be expected of them on account of the liability to variation common to this plant. Now, however, that plants of a well-known strain have been introduced, there is every hope that fruit of good quality may be successfully grown.'

JAMAICA.

An account of the experiments carried on in Jamaica is contained in the following extracts from the annual reports of the Director:—

'Seventy-five date palms were received from Algiers in November 1899. They were in tubs, pots, and wicker baskets. To enable them to recover from the effects of their long journey, and to get acclimatized, they were placed in the nursery, looked after there, and gradually exposed to the sun and hardened.

'In February and March 1901, sixty-nine of the plants were planted in prepared holes on the lawn between the Director's office and residence. The plants are placed 36 feet apart in rows which are 27 feet asunder. Five of the original plants have died.

'A 4-inch water main runs along the side of the drive, parallel with the palms, and connexions have been made with this by means of $\frac{3}{4}$-inch galvanized pipes with brass cocks, and laid to the root of each palm, so that each tree has its own supply of water.

'Three suckers have been established, so that we have at present seventy-three young trees'. (*Annual Report of Public Gardens and Plantations*, 1900-1.)

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* See p. 148.

'The date palms planted out last year have been manured and regularly irrigated when necessary, and, with few exceptions, they are making satisfactory growth.' (Ibid, 1901-2.)

'The date palms from Biskra, in Algeria, are growing in a most healthy way, and a few female trees have already flowered, but none of the male trees. They were badly attacked by the date palm fungus (*Graphiola phoenicis*), but by constant spraying with Bordeaux mixture, and by cutting away infected parts, this pest has been almost exterminated.' (Ibid, 1902-3.)

PORTO RICO.

The following note on the occurrence of the date palm in Porto Rico is taken from Cook and Collins' *Economic Plants of Porto Rico* :—

'The date palm has been introduced into Porto Rico, and while the plants reach a considerable size, particularly on the drier southern side of the island, it is not known that any fruit of good quality has been produced. Specimens of a date palm were obtained by Sintenis at Puerto Real, near Cabo Rojo, and it is in that region that the tree might be expected to thrive best in Porto Rico, and the results of experiments which have been made would be of interest.

'Although the date palm grows with apparent vigour in Porto Rico, it is not likely that it will ripen fruit of marketable quality, as the climate is too cool and too moist. The date reaches perfection only in desert regions, and while it can stand slight frosts, it must have exceedingly hot weather during the ripening season. That the tree will flourish is no indication that it will produce good fruit. In the Canary Islands an indigenous species of date palm is extensively grown for the sake of the leaves, which are made into baskets and serve other useful domestic purposes, but the fruit is nearly worthless, and genuine date palms which have been introduced do not succeed.'

FUNGOID DISEASE OF THE DATE PALM.

The only fungoid disease reported as attacking date palms in the West Indies is recorded from Antigua, Jamaica, and Trinidad. The following is extracted from a letter by Mr. J. H. Hart, F.L.S., forwarding the specimens from Trinidad :—

'I beg to forward you specimens of a disease which has attacked the leaves of newly imported date palms, nearly every one of which is affected. It appears to be a fungus differing from any previously seen here. I have on discovery of the attack at once treated the plants with Bordeaux mixture.'

The specimen was reported on by the Mycologist of the Department (Mr. L. Lewton-Brain) as follows :—

'The fungus attacking the date palm leaves forwarded by Mr. Hart appears to be *Graphiola phoenicis*, Poit., a fungus of doubtful affinities, but probably allied to the *Ustilagineae* or Smuts. The damage done by the fungus is quite a localized one, as the mycelium does not extend far beyond the pustules.

In the following pages will be found notes on the present position of the cacao industry in the West Indies, the exports of cacao from the different islands, the average prices, and other matters of interest, which will show that considerable progress has been made and that an increasing amount of land is being planted in cacao.

In a paper in the *West Indian Bulletin* (Vol. II, pp. 190-211) on the 'Fungoid diseases of cacao in the West Indies,' it was pointed out that losses had been occasioned by disease, but that these were apt to be overlooked on account of the large profits made on cacao plantations. Considerable attention has been paid by the Imperial Department of Agriculture to these diseases, and planters have been encouraged to do all in their power to keep them in check. The serious extent to which the industry can be affected by them is only too well shown by the case of the 'Witch Broom' disease of Surinam. In 1899 the value of the exports of cacao from that colony had amounted to £236,424 ; in 1903 this had fallen to £135,423—a decline which is attributed solely to the ravages of this disease. So far, fortunately, this disease has not appeared in the British West Indies, but the necessity for prohibiting absolutely the importation of cacao plants from Surinam, as advised by this Department, is clearly shown. The more prominent diseases that have appeared in these islands are the canker disease of the stem (*Nectria* sp.), the 'die back' disease (*Diplodia cacaoicola*), the Trinidad pod disease (*Phytophthora omnivora*), and the brown rot disease of the pod also caused by *Diplodia cacaoicola*. These diseases can all be held in check, chiefly by pruning and the care of wounds, and they do not appear to have caused any considerable loss.

It will be seen that cacao is an important item of export in several of these islands: this is more especially the case in Trinidad and Grenada. The value of the cacao exported from the former island now exceeds £1,000,000, while in the case of Grenada it is about £250,000. Next comes Jamaica, the value of the exports of cacao in the year 1901-2 being nearly £84,000. The exports of this product from St. Lucia were valued at £38,247 in 1900, when they formed 17 per cent. of the total exports of the island. Considerable quantities of cacao are also shipped from Dominica, St. Vincent, and British Guiana, while Montserrat and St. Kitt's-Nevis also produce small amounts.

The rise of the cacao industry in the West Indies is clearly shown in the following table giving the exports, in hundredweights, from the British West Indian Colonies during the past few years. It should be mentioned that in the case of some of the colonies the figures show the exports for the twelve months ending March 31 of the following year instead of December 31 of the year given in the first column. For the purpose for which this table has been compiled, however, this is immaterial. The table shows that the output from these islands has been very considerably augmented: the total exports (excluding those of St. Vincent) have risen from 335,817 cwt. in 1898 to 494,873 in 1902.

EXPORTS OF CACAO FROM THE BRITISH WEST INDIES.

Year.	Trinidad.	Grenada.	Jamaica.	Dominica.	St. Lucia.	British Guiana.	Total.
	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
1895	263,025	69,191	10,310				
1896	209,659	90,193	9,178				
1897	212,863	65,849	16,016		7,860	937	
1898	217,330	78,350	21,012	10,217	8,416	492	335,817
1899	260,942	79,472	20,041	7,980	8,490	1,107	378,032
1900	271,284	94,369	23,450	9,467	11,589	150	410,309
1901	268,750	93,857	39,953	8,989	5,866	1,085	418,500
1902	334,821	102,203	31,462	12,216	13,333	838	494,873

TRINIDAD.

The average output of cacao from Trinidad for the six years (1895-1900) was 239,184 cwt. It is shipped chiefly to the United States, the United Kingdom, and France.

The area returned as in cacao cultivation in 1897 was 98,000 acres; in the following year it had increased to 103,000 acres.

It is stated in '*The Food of the Gods*' that 'the Trinidad bean is the largest and finest flavoured and commands a higher price than any other from the West Indies.' The London prices of Trinidad cacao vary from 65*s*. to 80*s*. per cwt. The prices during the last six years have been as follows:—1897, 65*s*. to 73*s*.; 1898, 71*s*. to 75*s*.; 1899, 72*s*. to 80*s*.; 1900, 68*s*. to 75*s*.; 1901, 65*s*. to 70*s*.; 1902, 58*s*. to 67*s*. During the present year this cacao has been selling as follows: London, 58*s*. to 76*s*. 6*d*. per cwt.; New York, 12½c. to 15c. per ℔.; Canada, 13c. to 15c. per ℔.

GRENADA.

The output of cacao from Grenada has been increasing steadily until in 1902 it exceeded 100,000 cwt.

Grenada cacao does not obtain as good a price as the Trinidad article. To quote again from '*The Food of the Gods*': 'The bean is smaller than that of Trinidad, but the flavour is exceedingly good and regular, and the crop is bought up eagerly in the British and American markets'.

According to the report of Messrs. Lewis & Noyes, the prices of Grenada cacao have been as follows:—1900, 70*s*. to 73*s*. 6*d*.; 1901, 67*s*. to 69*s*.; 1902, 57*s*. to 64*s*.; 1903, 51*s*. to 62*s*. During the present year the prices have ranged from 52*s*. to 64*s*. 6*d*. per cwt. in London; from 12½c. to 13¼c. per ℔. in New York; and from 13c. to 13¼c. per ℔. in Canada.

JAMAICA.

The area in cacao cultivation in Jamaica has steadily increased during the past fifteen years. According to the returns of the number of acres in the various crops, as given in the *Handbook*, the area in cacao in 1889 was only 961 acres; ten years later this had increased to 1,721 acres, while in 1902 there were 3,548 acres returned as in cacao. The increase in the cultivation of cacao has been simultaneous with the extension of the banana industry, as on many estates cacao has been planted in the banana walks.

The price obtained for Jamaica cacao is less than for that from Grenada. According to official reports, prices have been as follows during the last five years:—1898-9, 50*s*. 10*d*.; 1899-1900, 60*s*.; 1900-1, 55*s*.; 1901-2, 42*s*.; 1902-3, 41*s*. 6*d*.

Jamaica, Dominica, and St. Lucia cacaos are usually classed together in the market reports; during the present year these have been selling at 50*s*. to 61*s*. 6*d*. in London.

DOMINICA.

Cacao is one of the two principal exports from Dominica. It is stated in Pamphlet No. 24, *Dominica, Hints to Settlers*: 'Messrs. Rowntree & Co., the great chocolate manufacturers of York, possess several large cacao estates at the north end of the island, and are rapidly increasing their output. The price of cacao has always been very remunerative and there is every reason to believe that the demand will go on increasing and thus keep up prices.'

BRITISH GUIANA.

Since 1895 the exports of cacao from British Guiana have not increased much, the average value for the last eight years being £2,121. There is no doubt that there is much land in the colony that is suitable for this cultivation, and there are signs of increased interest being taken in it. Chocolate has also been exported from British Guiana, the value of this export being £313 in 1895-6, £249 in 1896-7, and £38 in 1898-9, since when chocolate has not appeared on the export list.

A very good price is obtained for British Guiana cacao; this has varied during the present year between 64*s.* and 65*s.*, showing that the product of this colony comes, in quality, second only to that of Trinidad.

ST. VINCENT.

The decline in the exports of cacao from St. Vincent shows to what an extent this industry was affected by the disastrous hurricane of September 11, 1898. In 1897 the exports of this product were of the value of £4,514; in 1898 the value fell to £3,090, while in the following year it dropped to £116. The industry has since been resuscitated to some extent, and 87,455 ℔., of the value of £1,558 were exported in 1902.

OTHER CACAO-GROWING ISLANDS.

The other cacao-growing islands in the West Indies are San Domingo, Cuba, Hayti, Martinique, and Guadeloupe.

The total exports (in bags) of cacao from San Domingo for the five years 1898-1902 have been as follows: 1898, 44,580; 1899, 17,080; 1900, 74,874; 1901, 79,902; 1902, 39,000. Shipments go principally to Germany.

There has been a steady increase in the output from Cuba during the last three or four years. The exports have been as follows: 1900, 26,137 cwt.; 1901, 33,159 cwt.; 1902, 44,845 cwt. In 1902 the exports were of the value of £110,499, and all went to the United States.

The output of cacao from Hayti fluctuates: in 1898 it amounted to 1,000,000 ℔., in the year ended September 30, 1901, this amount had been quadrupled; in the following year there was a slight decline.

A considerable amount of cacao has been produced in Martinique, the average for the ten years 1890-9 being 48,720 cwt.

DISTRIBUTION OF CACAO PLANTS.

In considering the present position of the cacao industry in these islands it is of interest to observe the part played by the various botanical establishments. The following table shows, approximately, the number of plants distributed by these institutions, and at the same time brings out the fact that for some time extensive planting of cacao has been going on, from which it is only reasonable to conclude that, in the ordinary course of events, there should be a considerable increase in the output from the British West Indies.

The Imperial Department of Agriculture has paid a large share of attention to the cultivation of cacao. Manurial experiment plots have been maintained in Grenada, St. Lucia, and Dominica, and every effort has been made by the officers of the Department to encourage the cultivation of this product and, by demonstrating better methods of cultivation and preparation, to bring about an improvement in the quality of the product shipped.

In St. Vincent, after the hurricane of 1898, 9,842 cacao plants were distributed free, and 2,588 sold, from the Botanic Station. Cacao is also one of the crops that has received attention in connexion with the Land Settlement Scheme; over 4,000 cacao plants were distributed to allottees in the year 1903-4.

The number of cacao plants distributed from the Botanic Stations during the past two years has been as follows:—

		1902-3.	1903-4.
Dominica	...	8,277 (*a*)	15,059 (*b*)
Montserrat	...	3,388	—
St. Lucia	...	5,554	5,998
St. Vincent	...	3,389	5,140
Tobago ...	...	—	3,677

(*a*) In addition to 1,033 pods; (*b*) in addition to 1,753 pods.

The number of plants distributed from Hope Gardens, Jamaica, is as follows: 1900-1, 53,279 (and 622 pods); 1901-2, 38,654 (and 151 pods); 1902-3, 48,866 (and 147 pods).

These figures indicate that cacao plantations are being very considerably extended throughout the West Indies.

WEST INDIAN ANTHRACNOSE OF COTTON.

BY L. LEWTON-BRAIN, B.A., F.L.S.,

Mycologist on the staff of the Imperial Department of Agriculture for the West Indies.

From the earliest experiments with cotton in the West Indies, some of the bolls have been noticed to be attacked by a fungoid disease which, at first, I identified with the American 'anthracnose', merely from the appearance of the attacked bolls. Later, when specimens showing the fruiting stage of the fungus were observed, my earlier conclusions were much strengthened, as I found that the form of the spores and the spore-bearing organs of the fungus was practically identical with that described and figured by Southworth[1] and Atkinson[2] for *Colletotrichum gossypii*, Southworth, the fungus causing the disease called 'anthracnose' in the United States. The form and appearance of the spore-bearing organs and the spores will be described later in this paper. Writing of the West Indian anthracnose in my first preliminary article on 'Fungoid Diseases of Cotton' (*West Indian Bulletin*, Vol. IV, p. 265), I stated that 'this disease, which causes damage mainly when it attacks the bolls of cotton, is due to a fungus (*Colletotrichum gossypii*). It is one of the few fungoid diseases of cotton that occurs in the West Indies. Up to the present, it has not done any great damage in these islands.'

In November 1903, to make more certain of the identity of the fungus, specimens of affected bolls were sent to Mr. W. A. Orton, Assistant Pathologist, Bureau of Plant Industry, United States Department of Agriculture, at Washington; the bolls were taken from cotton growing in Barbados. At the same time I sent him cultures of a fungus taken from a diseased boll on another estate in Barbados. The following extracts are taken from Mr. Orton's reply:—

'A number of the bolls show discoloured spots closely resembling anthracnose, but I failed to find any fungus that is exactly like *Colletotrichum gossypii*. In many cases the diseased spots are overgrown with *Fusarium* and other fungi, probably saprophytic. This often occurs in this country, and in fact a large number of the specimens that I collected this summer for anthracnose were found to be covered with *Fusarium* spores when examined, leading me to suspect that this fungus is sometimes a facultative parasite. . . On a few bolls I found a fungus closely resembling *Colletotrichum gossypii*, except that the spores were much smaller than any I have ever seen; this is the same fungus that you sent me in one of your cultures. It has spores $\frac{8}{1000}$mm. to $\frac{10}{1000}$mm. by $\frac{3}{1000}$mm. to $\frac{4}{1000}$mm., while *Colletotrichum gossypii*, as described in Saccardo, and as measured from specimens in our herbarium,

has spores $\frac{11}{1000}$ mm. to $\frac{20}{1000}$ mm. by $\frac{4}{1000}$ mm. to $\frac{5}{1000}$ mm. and usually at least $\frac{16}{1000}$ mm. long. In other respects your fungus is like our anthracnose, as far as I am able to judge from a very hasty examination, and possibly this difference in the size of the spores is too small a characteristic to separate the two. Some of the bolls you sent appear to be dried up from purely physiological causes, that is, the failure of the plant to support them, and later to have been attacked by saprophytic fungi. Others have the definite spots characteristic of anthracnose. I am preparing a set of my cultures and specimens of cotton diseases to send to you, as I promised Sir Daniel Morris to do, and I hope to have them ready shortly.'

It will thus be seen that there can be very little doubt that, in Barbados in 1903, the cotton bolls were attacked by an anthracnose very similar to that found in the United States, and that associated with that disease is a fungus very similar to the *Colletotrichum gossypii*, which is known to be the cause of the American anthracnose.

Specimens of bolls with characteristic anthracnose spots were brought by Sir Daniel Morris from South Carolina, and specimens were also sent, as promised, by Mr. Orton. These bolls showed exactly the same appearance as those attacked by the West Indian anthracnose, taken from plants growing in Barbados.

In Barbados the disease is widely distributed. I have found bolls attacked by it, in greater or less abundance, in practically every field I have examined. It is, however, very rarely that any considerable proportion of bolls is affected. Specimens have been received from Montserrat showing the characteristic spots, but I have not seen the fruiting stage of the fungus on them. In British Guiana, Dr. Rowland, in an article on 'Cotton Diseases,' states that anthracnose is probably one form of the 'blasts' of earlier writers. In Jamaica, Mr. Cousins[4], in a note on cotton seed sterilization, states that *Colletotrichum* has been identified on seedlings. From Trinidad, Mr. J. H. Hart, F.L.S., has sent diseased bolls showing spots, which were probably due to anthracnose. It will be seen that the disease is distributed pretty well throughout the West Indies.

In nearly every case the disease has only attacked the bolls. Except in my infection experiments, to be described later, only one case of the disease attacking seedlings has come under my notice. As mentioned above, it has occurred on seedlings in Jamaica, and my experiments show that seedlings are readily infected, at least under certain conditions.

With regard to this point, Atkinson states: 'The fungus is probably widely distributed, but serious injury seems to be quite confined to certain localities. The author has observed it at quite a number of places in Alabama, but only at Brundidge was any very serious injury noted. At that place, in September 1891, 10 to 50 per cent. of the crop was destroyed on some plantations. In the vicinity of Auburn, its greatest injury seems to be confined to the young plants.'

Miss Southworth says that she had noted the disease only on the bolls. With regard to its severity, she states that 'in two cases, one from Alabama and one from Louisiana, it is reported as destroying 75 per cent. of the crop. In general, however, it seems to destroy from 10 to 25 per cent.'

SYMPTOMS OF THE DISEASE.

The Disease on the Bolls.—The characteristic appearance of anthracnose spots on cotton bolls has been described in my earlier papers, but the main symptoms may briefly be recapitulated here.

On the bolls, the disease first appears as small reddish or reddish-brown spots, the central part of each spot being somewhat depressed. The spot enlarges, and, as it does so, the central part becomes blackened and more distinctly sunken. We now have a black, sunken spot surrounded by a more or less ill-defined reddish margin. The earlier stages of the anthracnose spots are shown on the right hand, upper boll in fig. 1.

FIG. 1.—Cotton Bolls Showing Anthracnose. [From *The Cotton Plant.*]

The next stage in the development of the spots is due to the formation of spores of the fungus, which takes place in the centre of the depressions. The spores are usually produced in small pustules which break through the dead epidermis. The pustules are, however, as a rule, very numerous and so run together. The result is that we get practically one mass of spores in the centre of the depressed black spot. Examined singly the spores appear colourless, but when seen in the mass they have a bright, salmon-pink tint.

The appearance of the diseased spots now depends upon the number of spores that are produced. If this is small, the light-coloured spores against the black background of diseased tissue will cause the centre of the spot to appear greyish. If,

however, large numbers of spores have been produced, they form a mass covering the centre of the spot, and this then appears a bright pink. We then have a bright-pink centre to the diseased spot, this is surrounded by a depressed, black ring of diseased tissue, and this again by the reddish-brown margin which shows the region into which the advanced fungus hyphae are extending.

This stage is, of course, the most characteristic of the disease, and microscopic examination of it can leave no doubt as to the identity of the fungus causing it. It is shown on the top left-hand boll in fig. 1. It is not, however, frequently found in the field, as the spores are only produced under certain conditions, chiefly during wet weather. The disease, therefore, has often to be identified by the appearance of the spots alone. The fungus can often be made to produce spores, by bringing diseased bolls into the laboratory and keeping them in a moist chamber; under these conditions, however, saprophytic fungi frequently develop with great rapidity on the bolls and completely mask the *Colletotrichum*. The *Fusarium*, mentioned in Mr. Orton's letter which I have already quoted, is another source of error; it is frequently found on bolls and appears often to follow the *Colletotrichum*, its spores are also pink in the mass, though they are not produced in the centres of definite spots as are those of *Colletotrichum*. Microscopic examination, of course, reveals the difference at once; the spores of the *Fusarium* are curved and multicellular, while those of the *Colletotrichum* are straight and unicellular (fig. 2).

The anthracnose spots go on increasing in size, involving more and more of the boll, and as they do so, fresh spores are constantly produced (when conditions are favourable) from fresh parts of the fungus hyphae in the dead tissue. The colour bands surrounding the spots then, as Atkinson describes, move outward centrifugally.

Frequently, as the spots increase in size, two or more of them will coalesce, and so we get large, irregular, diseased areas which frequently spread over quite a large part of the surface of the boll. This is well shown in the lower bolls in fig. 1.

The amount of damage done to the individual bolls depends entirely upon the stage which they have reached when attacked by the fungus. The tissues invaded by the fungus have their growth stopped and they become dry and hard. If the boll is not attacked until it is fully grown, little damage may result, as the boll will open, and the lint will not be attacked. If, on the other hand, the boll is attacked while growth is still going on, the boll is practically spoilt. The growth of the unattacked portion causes the boll to become deformed. The drying up caused by the growth of the fungus brings on a premature ripening of the walls of the fruit, which either remains closed or opens slightly at the top. The lint is frequently invaded by the fungus, which is speedily followed by other saprophytic species and the lint is ruined, often becoming quite black from the fungus hyphae, etc., on it.

It is quite common to find bolls that have dried up from purely physiological causes, such as lack of nourishment in the

soil, etc. In this case, also, the lint is frequently blackened by the growth of saprophytic fungi. Some of the damage assigned to anthracnose is frequently really due to lack of sufficient nourishment, or to otherwise unfavourable external conditions.

The Disease on the Stem.—The effects of *Colletotrichum gossypii* on seedling stems are thus described by Atkinson[3], who was the first to report it on any other part of the plant than the bolls :—

'The fungus sometimes seriously affects the stems of seedling cotton, attacking the stem at the surface of the ground or just below, and causing the plant to wither and die, much as if it "damped off." The tissue reddens and shrinks frequently in longitudinal lines. The macroscopic appearances of the injury are usually quite different from those occasioned by the "sore shin" fungus. The stem is not apt to present the well-defined ulcer, or diseased depression, which is so characteristic of the injury from the latter. Seedlings are probably frequently diseased in this way from the spores which are lodged in the lint of the seed at the time of planting. In cultures of young plants in sterilized soil annoyance was sometimes caused by the development of the fungus under circumstances such that they could have been diseased in no other way than from spores which remained attached to the seed. Several times during the winter of 1892 and 1893 cotton seed from Alabama was planted in the forcing houses and botanical conservatory of Cornell University, and the fungus appeared sufficiently to "damp off" and disease several seedlings. This seed, which was gathered in the autumn of 1892, afforded a good illustration of the vitality of the fungus. Some of these same seeds were planted during the winter of 1893-4 and the fungus appeared upon the stem of the young seedling. In all cases where the seed was scalded before planting the fungus did not appear.'

This description applies very well to the disease as I have observed it in the West Indies, except that the tissue turns brown rather than red. The diseased spot does not spread round the stem as a rule, because before this can happen the seedling falls over and dies. The diseased tissue is found full of the hyphae, spore-bearing organs, and spores of *Colletotrichum*, but no definite spots and pustules are produced.

According to Atkinson's observations in the United States, 'the fungus does not produce any characteristic injury to the stem of well-developed plants which is noticeable, but it is frequently found in injured parts of the stem, and on the scars formed by falling leaves, where the dead tissue of the scar, especially in humid weather, invites its development.'

So far, I have not seen the disease on any part of the mature stem. An attempt to induce it, by introducing spores into a freshly made wound in the young, green part of the stem, was unsucessful.

The Disease on the Leaves.—Atkinson states that the disease very frequently occurs on mature leaves, especially

upon those that are sickly or injured mechanically. From its saprophytic possibilities it seems quite probable that the West Indian fungus would attack leaves that are dying, but I have no definite proof that it has so occurred. A number of infection experiments on mature leaves, of all ages, were all unsuccessful.

There is no doubt, however, of the power of the fungus to infect the seed-leaves or cotyledons. These are thick, fleshy, and much more tender than the mature leaf, and consequently form a much more suitable medium for the growth of the fungus.

Atkinson[3] describes the disease on cotyledons as follows :—

'While the seed is germinating, the spores caught in the tangle of lint still adhering to the seed-coats germinate and attack the fleshy cotyledons as they are slipping from the coats. The fungus attacks the edges of the cotyledons and destroys an irregular area bordering the middle portion. The cotyledons, being quite fleshy and succulent, form a suitable place for the development of spores, and the diseased area is marked by the bright-pink or roseate tint so characteristic of its profuse development on the fruit.

'The degree of success which attends the throwing off of the seed-coats by the cotyledons during germination probably bears a very close relation to their susceptibility to disease. After the young root has emerged from the seed-coat, or "hull," if the conditions are such as to cause the hull to dry and remain so, it is cast off by the cotyledons with difficulty and sometimes not at all. Frequently the hull clings to the extremities of the cotyledons, holding them firmly, while their bases are exposed to the light and consequently take on a green, healthy colour. The edges of the cotyledons thus held acquire a sickly, yellow colour, and frequently the effort to extricate themselves results in some abrasion of the tissue. In either case, the edges of the cotyledons, under such unnatural conditicns, are an easy prey to the anthracnose spores which fall on them from the tangle of the lint still on the seed-coat.'

I have been successful in infecting cotyledons both directly and by infecting the cotton seed before planting. I have never obtained, however, the pink colour due to the profuse development of spores, mentioned above. Possibly under the conditions of my experiments the cotyledons were destroyed too rapidly : possibly it may be an indication that the West Indian and American fungi are not identical.

ARTIFICIAL CULTURES.

Artificial cultures were made on the following gelatines :— Sugar-cane extract, cotton bolls and twigs extract, raisin extract and on nutrient gelatine. The preparation of these is given below. The fungus has also been grown on sterilized slabs of sugar-cane, and on baked slices of sweet potato. Growth was vigorous on all these media. It was noticeable, however, that on the nutrient gelatine spore production was much less abundant than on the other media. The pink colour due to masses of spores was visible, for example, in three days on most media,

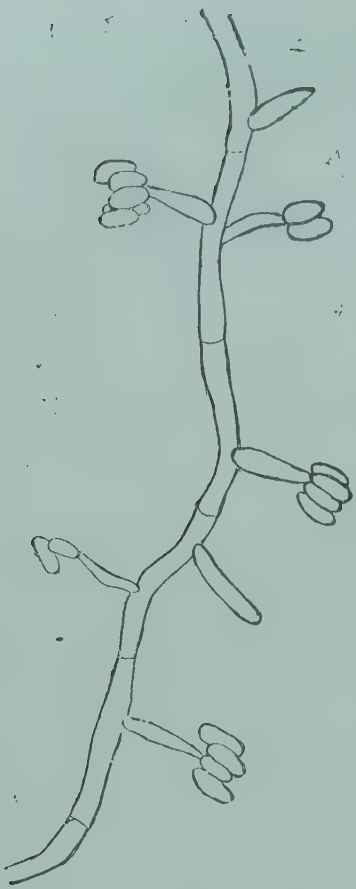

Fig. 2. Hypha of *C. gossypii*, var. *barbadense*, with numerous basidia, showing crown clusters of spores. [× about 300.]

but had not appeared on cultures twelve days old on nutrient gelatine. The cultures were all made at the temperature of the laboratory, which varies slightly, but may be taken as about 30° C.

Sugar-cane Extract.—Small pieces of sugar-cane were boiled in a flask of water for one hour. When cool, the juice was filtered and gelatine added to the filtrate in the proportion of 20 grammes to every 100 c.c. of the extracted juice. This was heated on the water bath till completely dissolved, and filtered while hot.

Raisin Extract and Cotton Extract.—Raisins and young cotton bolls were treated in a similar manner.

Nutrient Gelatine.—In this case half a gramme of ready-prepared meat extract was boiled in 100 c.c. of water, 3 grammes of peptone and half a gramme glucose being added while boiling. When completely dissolved, sufficient sodium phosphate was added to render the solution slightly alkaline. Twenty per cent. of gelatine was dissolved in this on the water bath and the solution filtered hot.

The high percentage of gelatine used is, I have found, necessary in this tropical climate.

The spores are somewhat variable in shape and size (fig. 7); most often they may be described as oblong, with rounded corners. They germinate readily in a few hours in nutrient media. Each spore may produce two or three germ tubes, which soon branch. The growth of the mycelium is very regular in plate cultures; the hyphae at the periphery are looser than those towards the centre, the spaces being closed in by further branches as the mycelium becomes older.

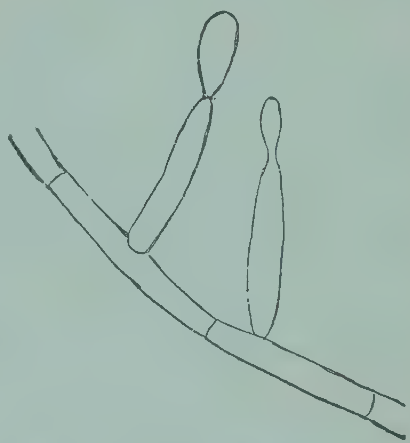

Fig. 3. Two basidia showing spore formation. [× about 640.]

Spore-bearing organs and spores are produced in a very short time, certainly within forty-eight hours; Atkinson says within eighteen hours. The earliest spore-bearing organs to appear are the so-called 'basidia,' and it is on these that the pink-coloured spores are produced. The basidia are short, pointed hyphae, generally only one cell long (figs. 2, 3, and 4), though Atkinson says they may be two or three cells long. In Miss Southworth's figures the basidia are unicellular.

A spore in course of formation from a basidium is shown in fig. 3. In this case the spore is being abstricted, but it may be cut off more abruptly, in which case it will have a less pointed basal end. The basidia vary in length, those shown in the figures are about double the length of the spores. In cultures, the basidia may be more or less separated, occurring singly along a hypha (fig. 2), or they may form groups or clusters (fig. 4). Naturally, they occur in the clusters which produce the pustules of spores already mentioned.

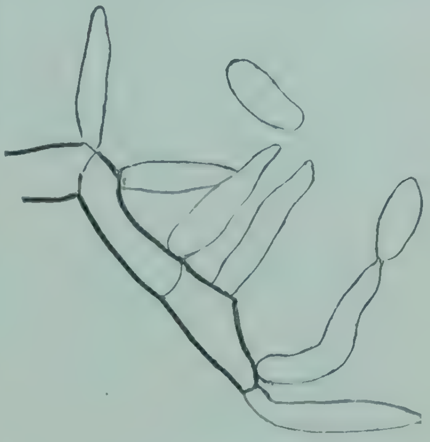

Fig. 4. Cluster of basidia with spores. [× about 640.]

When a spore has been cut off from the end of a basidium, this again produces another spore, the first one is then pushed to one side and this process continues, so that in a few days we get beautiful 'crown clusters' composed of conidia lying side by side at the ends of the basidia (fig. 2).

The second type of spore-bearing organ is the so-called 'seta.' A seta is a much stouter organ than a basidium (compare figs. 3 and 5), it is multicellular, and its walls are much harder and thicker than those of the basidium. The basal part of the seta is a very dark brown, but the colour gets lighter towards the tip. Spores are cut off from the tip of the seta in much the same way as from the basidium (fig. 5). These spores are practically identical with those formed on the basidia; Miss Southworth says that they appear to be rather smaller than the others, but that they cannot be distinguished in artificial cultures. These setae are characteristic of the genus *Colletotrichum*, but *C. gossypii* is the only species, so far as I know, in which they produce spores.

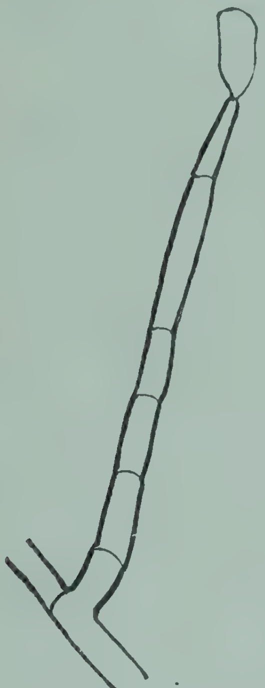

Fig. 5. Seta with spore. [× about 640.]

With regard to their occurrence on nutrient media, Atkinson states that 'in cultures on nutrient agar' he has never 'observed setae to develop in such numbers nor so perfectly as they do naturally on the host.'

This is borne out by my cultures. On the nutrient gelatine, setae occurred very sparingly, but on sugar-cane extract they appeared abundantly and perfectly.

The earliest appearance of setae on sugar-cane extract gelatine noticed was in a culture seven days old; they are generally abundant in cultures about the eleventh day. They are produced in the central, older part of the mycelium, and are produced in such abundance that they give the mycelium

a light-brown colour, which merges into the pink colour of the part bearing basidia and this again into the white of the sterile mycelium of the border.

A third type of reproductive body is present in older cultures, and is also found in the tissues of the host plant. This is the so-called 'special cell' and appears to be a kind of rudimentary sclerotium. This is described by Atkinson[3] as follows:—

'Besides the production of spores, certain branches, either remote from or near the centre of growth, produce at their ends peculiar enlarged cells, olive-brown in colour and varying in outline, but always of greater diameter than the hyphae which bear them. These bodies frequently produce immediately a normal hypha resembling the others of the mycelium. This in turn may soon produce another bud, or may grow to a considerable length and produce basidia and spores, or develop spores soon after its origin from the bud like an ordinary basidium. In many cases the gemma immediately begins to bud in an irregular manner, producing cells similar in colour, but very closely compacted together into an irregularly oval, or elongated or flattened, imperfect sclerotium. After one or two weeks' growth a large number of these gemmae and imperfect sclerotia are developed near the centre of growth. At the same time, the basidia have become very numerous at this point, arising from the mycelium or by the branching of older ones, and the mass of spores assumes a roseate tint. Cultures were also started in pure water and in a weak nutrient medium. In water the germ tubes, when once or twice the length of the spore, almost invariably produced gemmae. If these developed other tubes, it was only to give rise to other gemmae. In no case at that time were spores produced nor any appreciable length of mycelium. In the weak nutrient medium the gemmae were produced freely; also a number of hyphae produced spores. While the vegetative growth exceeded that of the spores sown in water, there was but little compared with that of spores sown in a rich medium, and the spores did not live so long. These gemmae are sometimes spoken of as secondary spores. They are not secondary spores in the usual acceptance of that term. They do not become freed from the mycelium except by accident or by the dying of the thread to which they are attached, in which case they are more properly gemmae. Their frequent later development into compound gemmae by budding would strengthen this view, and indicate that they are rudimentary sclerotia, or perhaps presage the development of pycnidial or ascigerous stages, as yet unknown in this genus.'

The presence of these dark olive-brown cells, in large numbers in the older parts of the mycelium, helps to give this its brown colour. They were also present in large numbers in infected seedlings. The appearance of the earlier stages of these cells is well shown in fig. 6, taken from a culture on sugar-cane gelatine. The upper of the two shown has at once given rise to an ordinary vegetative hypha. The lower has commenced to bud; later stages of this show a

thick clump of dark-brown cells, which represent small sclerotia. Spores are drawn in this figure, to the same scale with the camera lucida, to show the relative size of the special cells.

As with the setae, the special cells are produced much less abundantly on nutrient than on sugar-cane and other gelatines. They probably function as resting cells, being apparently more resistant than the spores proper and the vegetative hyphae; it may be that the remarkable vitality of the mycelium to be described later is to some extent dependent upon their presence.

The cultures on sugar-cane slabs and slices of sweet potato showed no special features; the mycelium rapidly spread over the surface of the medium, and spores were produced in abundance, just as in the gelatine cultures.

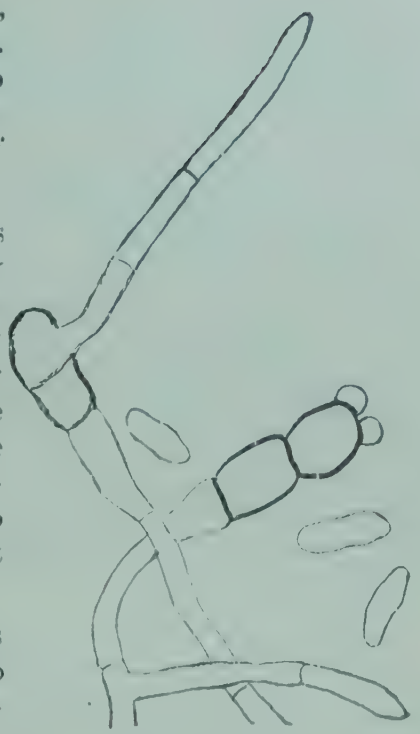

FIG. 6. 'Special cells,' one giving rise to a hypha, the other apparently budding. [× about 640.]

INFECTION EXPERIMENTS.

Inoculation experiments were carried out mainly with seedlings grown under bell-jars. The experiments have been worked at during the season between the ripening of one crop and the next planting, so that trial infections of bolls have not been possible. There can, however, be little doubt that the fungus I have isolated, the botanical characters of which have been described above, is really the cause of the boll disease. This would seem certain both from its general association with the disease and its general agreement with the true *Colletotrichum gossypii*, which is known to be the cause of the American anthracnose.

The growth of the seedlings under glass naturally rendered them more liable to infection; the epidermis under these conditions is much less strongly cuticularized and the habit of the seedlings generally is lank and weak. This plan was, however, necessary to secure uniformity of conditions.

Inoculation experiments with Seedlings.—On July 5, four seedlings, growing in ordinary garden soil in a pot, were infected. The cotyledons (seed-leaves) of these seedlings were just appearing above the surface of the soil. Three of the plants were infected by placing on the cotyledons a drop of sterilized water in which spores of the fungus had been shaken up. The fourth seedling was infected by placing on it with a sterilized needle a small piece of the fungus mycelium. Two other seedlings growing in the same pot were not inoculated: these were seedlings which had had difficulty in withdrawing their cotyledons from the seed-coats and were consequently far more liable to attack by *Colletotrichum* than the four infected ones.

By July 9, the cotyledons of all the inoculated seedlings were badly attacked. Light-yellow streaks first appeared in the leaves, these rapidly turned brown; the unhealthy appearance soon spread over the entire leaf. Microscopic examination of one of the cotyledons showed the whole tissue to be full of *Colletotrichum* mycelium and spores; setae and sclerotia were especially abundant. By July 11, the cotyledons of all the infected plants had been transformed into a dark-brown, watery masses, and were falling down. The stems (hypocotyls) showed dark, longitudinal streaks wherever they had been touched by a piece of the infected cotyledons. The two non-infected seedlings had, all the time, been perfectly healthy; they had finally thrown off their seed-coats and the contrast between their dark-green, healthy cotyledons and those of the other four seedlings was very marked. The stillness of the air, under the bell-jar, prevented infection of one seedling from another.

On July 15, five young seedlings, growing as before in garden soil, under a bell-jar, were inoculated by placing on the cotyledons drops of sterilized water with spores of *Colletotrichum.* Another lot of four seedlings of the same age, growing also under a bell-jar, was kept as a control; drops of sterilized water without spores were placed on the cotyledons.

By July 19, all the infected seedlings were badly diseased, the cotyledons were dark-brown and watery. In the control pot, all four of the seedlings were perfectly healthy, in spite of the fact that in two cases the cotyledons had been torn by the testa.

On July 15, six cotton seeds were soaked for three quarters of an hour in water containing spores of *Colletotrichum.* They were then taken out, drained, and planted as before. By July 25, four of the seedlings showed distinct infection of the cotyledons, the other two were more doubtful.

By July 29, the cotyledons of the four seedlings were rotten, two of these seedlings were also attacked at the surface of the soil. The cotyledons of the other two seedlings were now distinctly attacked. It is noteworthy that the cotyledons of the four seedlings first distinctly attacked had all been withdrawn with difficulty from the seed-coats. The two seedlings that resisted longer had withdrawn their cotyledons without injury. A control showed no infection.

On July 28, six cotton seeds were soaked in sterilized water in which spores of *Colletotrichum* had been shaken up for one hour. Six other seeds were soaked in sterilized water. The two lots were planted in separate pots in ordinary garden soil. By August 6, five of the infected seeds had germinated, three of these seedlings had rotted off as in the other experiments. Only three of the seeds in the control pot germinated: these seedlings were quite healthy.

The next experiment was intended to test the possibility of soil infection. On August 9, a pot was filled with ordinary garden soil and the whole steamed for an hour, partially to sterilize the soil. Ten cotton seeds were planted in this and

the soil was infected by watering it with water containing spores and mycelium of the fungus. Ten other seeds were planted in ordinary soil without any sterilization and watered with pure water.

By August 15, eight seeds had germinated in the infected pot. Of these seedlings, five were badly attacked and killed down, one was slightly attacked. Of the five seedlings killed, four were attacked just above the surface of the soil in the manner described on p. 182; the one slightly attacked seedling was infected at the same spot. One seedling only was attacked on the cotyledons and this was one that had great difficulty in withdrawing its cotyledons from the seed-coat, they were in fact never entirely withdrawn. Two days later, another seedling had fallen over and was dead, and the seventh showed slight infection at the base of the hypocotyl. In the control pot, also, eight seeds germinated: these were all quite healthy on August 17.

Previous inoculation experiments similar to this had shown that, if the conditions are kept too moist, the seeds do not germinate properly at all; the seedlings are all killed off before the cotyledons appear above the surface of the soil.

These experiments with seedlings show that these may be attacked by *Colletotrichum* in at least three ways. They may be infected, either on the cotyledons or the hypocotyls, directly by the spores; they may be infected by spores remaining attached to the seed-coats, and this is especially the case if the cotyledons become injured in being withdrawn from the testa; finally, they may become infected by spores or mycelium of *Colletotrichum* in the soil, in this case they may either be attacked at or about the surface of the soil, or if the seed-leaves are injured these may be attacked.

Inoculation experiments with mature Leaves.—A considerable number of young cotton plants have been inoculated with *Colletotrichum* spores and mycelium. The plants were covered at the time of inoculation with bell-jars and on healthy leaves in all stages of growth drops of water with anthracnose spores were placed. Drops of water only were placed on leaves of other plants as controls. In every case, controls and inoculations, the leaves remained perfectly healthy except that in one or two instances the leaves were attacked by the cotton rust (*Uredo gossypii*).

It would appear, then, that healthy leaves, even under conditions most favourable to the disease, are but little liable to become infected by anthracnose. Atkinson, as mentioned above, says that only leaves that are sickly are attacked. The importance of this point, of course, depends on the fact that if leaves are attacked they would form a medium on which the fungus could live and reproduce and so tide over the period between the seedling stage and the stage at which the cotton plant is forming bolls.

Inoculation experiments on the Stem.—Inoculation experiments on stems have also been tried without any positive results. Water with spores has been placed on young parts of

the stem. In one case a wound was made in the cortex of a young stem and spores introduced into the wound. This also was unsuccessful. The wound turned black at the edges, just as ordinary wounds do, but afterwards healed up without any further results.

Inoculation experiments on the Bolls.—Owing to the season, I have not been able to carry out any inoculation experiments with cotton bolls. The only infection experiment with the American anthracnose I can find described is given by Miss Southworth [1] as follows:—

'One infection experiment was made on three healthy bolls. The spores were inserted in a cut, and the fungus was produced in great quantities all around the cut. The value of this experiment was lessened by the fact that the fungus also appeared on one of the check bolls and that all were taken from a field in which the disease was present. The fact, however, that on the infected bolls the fungus was confined to the vicinity of the cuts is evidence that it was caused by the inserted spores.'

IDENTITY OF THE WEST INDIAN ANTHRACNOSE.

As will be seen from what has been given above, the West Indian disease of cotton, which I have called anthracnose, is very similar to the disease known by the same name in the United States. More than that, the fungus causing the disease, which I have described, is very similar to *Colletotrichum gossypii*, the cause of the American anthracnose. So much is this the case that the figures of *C. gossypii*, given by Miss Southworth [1] and Professor Atkinson [2], could easily have been used to illustrate this paper. The differences in the behaviour of the West Indian fungus that I have noted are very slight, and perhaps might disappear on more thorough investigation.

The first indications of any difference in the fungus were given in Mr. Orton's letter quoted on p. 178. At that time I was unable to measure the size of the spores, but Mr. Orton did so and found that they measured $\frac{8}{1000}$ to $\frac{10}{1000}$ mm. long, while those of the true *Colletotrichum gossypii*, he says, are usually at least $\frac{16}{1000}$ mm. long, the limits of length being $\frac{11}{1000}$ to $\frac{20}{1000}$ mm. Miss Southworth's original technical description of *C. gossypii* [1] may be quoted here:—

'*Colletotrichum gossypii*, n.s. On cultivated cotton, may occur on any part of the plant, especially injurious to bolls. Sori orbicular, dark coloured, or covered with a pink powder. Acervuli erumpent, distinct only when young. Spores irregularly oblong, usually with a light spot in the centre, often acute at one end, colourless singly, flesh coloured in mass, borne on short basidia or long setae. Basidia colourless, varying in length, at least longer than the mature spore, very rarely branched, borne on a stroma of varying thickness, $\frac{11}{1000} - \frac{28}{1000} \times \frac{5}{1000}$ mm. Setae occurring singly or in tufts, more abundant in older specimens, dark-brown at base, but nearly colourless at the apex, septate, often irregular in outline straight or flexuose, rarely branching, often bearing spores.

Mycelium septate, intra- and inter-cellular, usually colourless, producing secondary, dark-coloured spores, especially when it has simply the form of a germ tube. Stroma of varying thickness, often penetrating the plant tissues for some distance, becoming dark coloured with age or where setae are borne.'

It will be seen that the West Indian fungus agrees with this description, excepting in the size of its spores. Professor Atkinson[3] says that these 'vary greatly in size from [illegible] to $\frac{9}{1000}$ mm. in diameter, by $\frac{15}{1000}$ to $\frac{20}{1000}$ mm. in length.'

My second series of cultures was started from a boll from a different estate in Barbados, not that from which the specimens were sent to Mr. W. A. Orton. The spores in this series, measured again and again here, were $\frac{4}{1000}$ to $\frac{5}{1000}$ mm. in diameter by $\frac{11}{1000}$ to $\frac{14}{1000}$ mm. in length. As regards length, these spores, then, come within the limits given by Miss Southworth, but they do not come within the limits given by Professor Atkinson. The spores are also somewhat more narrow than those of the original *C. gossypii*. The difference in size in the spores is well shown in fig. 7; these were drawn side by side to the same scale with the camera lucida.

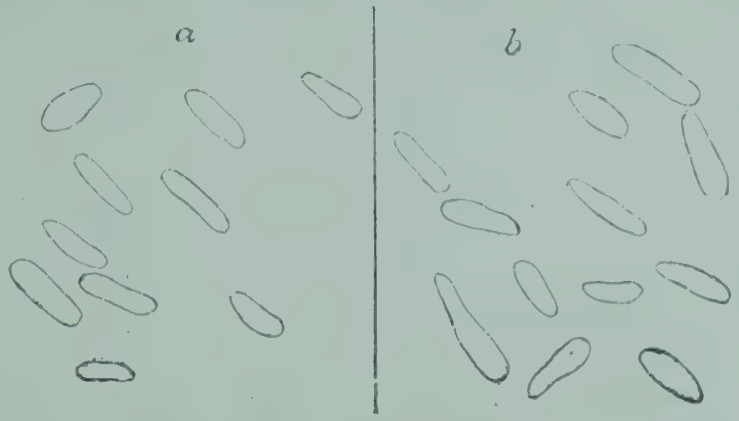

FIG. 7. Spores of (a) *C. gossypii*, var. *barbadense*.
(b) *C. gossypii*.
Same magnification, showing difference in size.

Mr. Orton kindly sent me a tube culture of the true *Colletotrichum gossypii* on gelatine. From this I made cultures parallel to those of the West Indian *Colletotrichum* on the different gelatine media. The fungi on these appeared very similar, showing much the same differences as one another on the various media. The size of the spores, however, remained constant, and it was from two of these cultures that the drawings for fig. 7 were made. There were slight differences in the two fungi in their modes of growth, almost too slight to be described. It seemed to me, however, that the American fungus was somewhat more rapid in its growth, and somewhat less hardy and vigorous, under the conditions obtaining here, than the West Indian one.

On the whole, I am inclined to think that the two fungi are not specifically distinct, but that the West Indian fungus is merely a variety of *Colletotrichum gossypii*, which has become slightly modified from the parent form in becoming acclimatized to West Indian conditions. Should this prove to be the true state of affairs, I should suggest the name *C. gossypii*, var. *barbadense*, n.v., for the West Indian fungus,

distinguished from the typical form by its spores being generally less than $\frac{15}{1000}$ mm. long and only $\frac{4}{1000}$ mm. broad.

The problem of identity is an interesting one from the scientific point of view. It may be that further study would show greater differences than any I have mentioned. On the other hand, there are indications that the size of the spores is not a constant character, and the two fungi may be identical. For all practical purposes the differences may, so far as I can see, be ignored.

General Remarks.

The most noticeable feature about the *Colletotrichum* is the vitality of its mycelium. Miss Southworth[1] gives the following note on this point:—

'The fungus retains its vitality under very adverse circumstances. Some specimens of diseased bolls were allowed to lie in the heated air of the laboratory for a month or more. The pink spore powder was then entirely washed from the surface, a piece cut out and soaked, and placed under a bell glass. In three days the surface again showed small masses of pink spores that had been produced since the fungus was put under the bell glass.'

The following facts illustrate this point even more strikingly. The tube culture sent me by Mr. Orton was dated November 16, 1903; for various reasons this was not opened until July 7, 1904. By this time the gelatine had dried up to a thin layer on the side of the tube, and it seemed impossible that the fungus should have withstood dessication for so long. However, plates were infected from this gelatine; the dried-up mycelium soon commenced to grow, and four days later was producing spores in abundance. The mycelium is thus capable of withstanding dessication, not to speak of climatic changes, for eight months.

Another point brought out in these cultures is the marked saprophytic habit of the fungus. As has been shown, it will grow well, and reproduce itself freely, on such widely different media as meat extract, a decoction of cotton bolls, sugar-cane slabs, and slices of sweet potato.

It is most markedly parasitic upon somewhat fleshy, delicate tissues, such as those of the cotyledons, seedling stems, and the bolls of cotton. It does not seem able to infect healthy mature leaves or healthy stems. It is probable that stems and leaves are only attacked when they are already dying or dead.

It was at first thought possible that the fungus gained entrance to the plants at the seedling stage, and that the mycelium spread through the tissues and so infected the bolls, as it were, from the inside. This is what happens in a good many of the smut fungi (*Ustilagineae*). There is, however, no evidence that the mycelium penetrates deep into the tissues of the stem and spreads from there to the leaves and bolls. In my experiments, too, when seedlings were attacked they were always killed off, though this need not necessarily be the case with plants growing in the open. Then, as Professor Atkinson

points out, the fungus very quickly establishes itself and produces spores in a few days.

It would seem, then, probable that the life-history of the fungus runs as follows: It passes over the time from the end of one planting season to the beginning of another as mycelium in diseased bolls, etc., lying about the field; this mycelium remains alive and is wakened to reproductive activity again by wet conditions. In this way spores are produced ready to infect the seedlings as they appear above the surface of the soil. On these seedlings the fungus gets another start and passes from these to dead and dying leaves, leaf-scars, etc., thus hanging on until the bolls are being formed. The bolls are then infected, and each one attacked is a fresh starting point for the disease, the fungus on each producing fresh crops of spores as the conditions become favourable.

Another way in which the fungus may tide over from one planting season to another is by means of spores attached to the seeds. As the fungus grows on and in the bolls, not only spores but mycelium might easily become held in the coats of the seeds. My experiments show that spores held in this way can infect seedlings. Professor Atkinson, as noted on p. 182, attaches great importance to this method of carrying over infection from one season to another. He says that anthracnose spores have been found to germinate when taken from diseased bolls after five months.

These points are of importance practically as showing our most promising methods for dealing with the disease. It is of the utmost importance, evidently, to destroy all diseased bolls as soon as possible. If these are left the fungus will not only go on producing fresh crops of spores, and so infect healthy bolls throughout the crop season, but it will also live in them until the next planting season and so be ready to attack the next crop. When possible, diseased bolls should be removed and burnt as soon as they are noticed. When this cannot possibly be done, at least a clean sweep should be made at the end of the crop season. When burning is impossible, the diseased bolls, etc., could be collected and buried in a cane field after being thoroughly mixed with lime.

Burning, however, is the best treatment wherever it can be applied. Too often, I have seen old fields of cotton left standing after all the crop has been gathered, and when nearly all the bolls remaining are worthless or diseased. Such plants should have been got rid of long before.

For the same reasons cotton should not be planted on the same field two consecutive seasons. This, of course, applies especially when the crop has been badly attacked the first season; but rotation should be practised whether this has been the case or not.

Another point is to prevent the disease spreading by means of spores, etc., attached to the cotton seed. For this purpose all the seed imported into the West Indies this year by the Imperial Department of Agriculture has been steeped in a 1:1,000 solution of mercuric chloride (corrosive sublimate) for one hour. This is a precautionary method which should always

be carried out. The germinating capacity of the seeds has been proved to be unaffected by the treatment.

Another preventive measure is, when selecting seed for planting, to select only that from healthy plants. This will finally result in breeding a resistant race of cotton, besides avoiding the chance of directly spreading the disease by spores on the cotton seeds. Mr. Webber[5] thus refers to this point:—

'Anthracnose, another serious disease produced by a parasitic fungus, is much worse on certain varieties than on others, and individual plants have been observed to vary considerably in degree of susceptibility. Here again there is evidence of an opportunity for the plant breeder to secure material for experiments in the breeding of immune varieties.'

Spraying I do not think is likely to be a practical remedy for anthracnose. It would have to be carried out at a time when some, at least, of the bolls are opening, so that, without extreme care on the part of the operator, a great deal of the lint might be badly injured. Whether the application of dry fungicides might be more practicable is a matter for experiment. I can find no record of any successful fungicidal treatment of anthracnose.

A word may also be said here about the best season for planting; the development of anthracnose and its spread in a field is much more rapid in wet weather than in dry. Consequently, so far as this disease is concerned, it will be better to plant cotton at such a time that the development and ripening of the bolls takes place in dry weather. Opinion in Barbados is divided between early planting—in May or June—and late planting—in September. In Montserrat and St. Vincent early planting seems to be generally favoured. With early planting, if the weather is very wet in December and January, anthracnose is likely to be abundant: on the other hand, the crop may suffer from drought in a dry December and January, if planting is too late. At any rate, the relative abundance of anthracnose should be borne in mind in the experiments which are being carried out to ascertain the best season for planting cotton in the West Indies.

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(3) George F. Atkinson: 'Diseases of Cotton.'
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(4) H. H. Cousins: 'Treatment of Cotton Seed in Jamaica.'
Bulletin of the Department of Agriculture, Vol. II., p. 136. Jamaica, 1904.

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THE MUSCOVADO SUGAR INDUSTRY IN BARBADOS AND THE LEEWARD ISLANDS.

BY HIS HONOUR ROBERT BROMLEY.
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The muscovado process of sugar making dates back to the time when the sugar-cane was first introduced into the West Indies, and it is astonishing to note how little change has been made in the process during the 250 years that it has been in vogue.*

In the early days of the industry only animal and wind power were available for the heavy work of driving the mills.† Plantations were therefore laid out to produce from 100 to, at the most, 300 tons of sugar, and equipped with factories of corresponding size. When steam power was introduced these small factories were perpetuated, and only in a few cases, where contiguous plantations happened to be held by the same owner, has centralization been attempted. In Barbados, for example, there were, in 1897, 440 estates, of which only twenty-three are over 500 acres, of the remainder, 175 are over 200 acres, 103 are over 100 acres, and 139 of less than 100 acres.‡ Only ninety-nine estates employ steam power, the remaining 341 being dependent on wind power. There is no up-to-date machinery, and only eight plantations, aggregating 5,000 acres, have vacuum pans, all erected prior to 1884. There is no triple-effect machinery on any estate in Barbados.

In most parts of the world the muscovado process of sugar making has given way to the vacuum pan, but it is a curious fact that the three British West India Islands most dependent on

* The Hon. F. Watts' Report on Sugar Industry, Antigua, January 1896.
† The Hon. O. Bennett. Paper on Central Factories, Antigua, March 1896.
‡ *Report of Royal Commission*, 1897. App. A., pp. 96-7.

their sugar crop, namely, Barbados, St. Kitt's, and Antigua,* still continue to make, almost entirely, muscovado sugar by a process which is admittedly antiquated, imperfect, and wasteful. The explanation as to why these islands have not adopted improved machinery in the past, when the industry was a paying one, is briefly as follows:—In all of them cultivation has been most carefully carried on, and the soil produces a cane containing juice of exceptional richness.† There has always been a plentiful and cheap supply of labour, so that in prosperous times the profit derived from muscovado sugar was so good that the proprietors of plantations were content and had no motive arising from a felt necessity for adopting improved machinery. Until a few years ago the profit on muscovado sugar was still good, and it is only recently that severe losses have been sustained and the credit of the industry has fallen so low that it is now almost impossible to raise money at a fair rate of interest for the erection of new machinery. ‡ In those West Indian Colonies, on the other hand, where improved machinery has been adopted in the past, as in Demerara and Trinidad, the reason for this advancement is to be found in two factors; namely, (1) the canes are less rich in sugar, and the juice is of a lower degree of purity; and (2) the high cost of labour, which makes the cost of cultivation higher.

This view has been clearly stated by Dr. Watts, in a paper read before the Antigua Agricultural Society in 1894, in which he says: 'The quality of the juice has probably had an important bearing on improvements in sugar making in any given district. In places like the Leeward Islands, Barbados, etc., where the juice is rich and with a small glucose ratio, muscovado sugar is easily made, and as the cost of the necessary plant is small, the muscovado process has suited the industrial conditions of those places. . . . In those places, on the contrary, where the glucose ratio is high, as in Louisiana, and I think I may add Demerara and Trinidad, muscovado sugar could only be made with difficulty, hence it became absolutely necessary to adopt other processes, and it is in these places that the greatest improvements in sugar-making machinery have taken place, and the triple-effect and vacuum pan are regarded as the only remunerative sugar-making appliances.'

Before going fully into the arguments for and against the continuance of the muscovado system in the Leeward Islands and Barbados, it will be as well to state briefly the main differences between the two kinds of sugar and the systems by which they are made.

Muscovado sugar is usually made in small factories producing from 100 to 500 tons of sugar per annum, and the process, as at present carried on, is a crude one, the sugar being made in open pans and the crushing of the canes being very

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*A small, up-to-date factory has lately been completed in Antigua, and a larger one is now also being erected.

† *Report of Royal Commission*, 1897. App. C., part iii, p. 156.

‡ *Report of Royal Commission*, 1897. App. C., part xi, p. 157.

imperfect. The sugar produced is of an inferior quality hardly ever polarizing more than 89° to 90°, and owing to its moist nature often losing, when shipped, upwards of 5 per cent. by draining.* The machinery, on the other hand, is inexpensive, and the molasses much richer and more valuable than that produced in factories making a higher-grade sugar. In a few words, the advantages and disadvantages of the muscovado process are:—

1. *Advantages.*—

(*a*) Owing to the small size of the factories and the crude machinery used, they are inexpensive to maintain and comparatively cheap to erect.

(*b*) The molasses command a considerably higher price than the molasses usually produced by higher-class machinery.

2. *Disadvantages.*—

(*a*) Owing to the present imperfect crushing, only about 55 per cent. of the juice is extracted from the canes.

(*b*) The sugar produced is of a low grade.

(*c*) The sugar loses something like 5 per cent. by draining when shipped.

Dark or grey crystals are produced for the most part in central factories capable of making not less than 3,000 tons of sugar per annum. [N. B. It is undesirable, for various reasons, which it is impossible to go into here, that these factories should be smaller.] The process by which this kind of sugar is produced is what is known as the vacuum pan with triple-effect, which, by evaporating the juice in vacuo and thereby reducing its boiling point, increases the yield of crystals and produces a sugar polarizing about 96°. Owing to the improved methods of crushing the canes employed in such a factory, from 70 to 72 per cent. of the juice is extracted from the canes.

The molasses, however, are usually not nearly so valuable as those produced by the muscovado process. Briefly stated, the advantages and disadvantages are:—

1. *Advantages.*—

(*a*) Seventy per cent. of the juice is extracted where usually 55 per cent. is extracted by the muscovado process.

(*b*) The sugar produced is of a higher quality and commands a relatively higher price.

(*c*) Greater centralization.

(*d*) By the central factory system the planters can devote all their attention to growing the canes, whereas under the old system they are both cane growers and manufacturers.

(*e*) There is no loss by draining when the sugar is shipped.

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* *Report of Royal Commission*, 1897. App. C., part ix, p. 157.

2. *Disadvantages.*—

(*a*) Central factories require a large outlay of capital to erect, and are costly to keep up.

(*b*) The molasses are usually of little value.

Such are briefly the advantages and disadvantages of the two systems. At first sight, and considered apart from local conditions, there can be no doubt that the central factory system has the appearance of being the better, yet there are people of considerable experience who maintain that, so far as Barbados, at any rate, is concerned, this is not so, and that the muscovado system is best suited to the industrial condition of these islands, and that they would make a mistake if they were to replace their present process by more modern machinery producing a superior class of sugar, because there is a definite market for muscovado sugar and the total quantity produced is relatively quite small.

This view is supported by the following arguments :—

(1) That the muscovado system is well suited to local conditions which make it difficult to obtain the combination of a sufficient number of estates to support a central factory.

(2) That, although the method of manufacture is admittedly imperfect and wasteful, yet, on the other hand, it is simple and easily understood, and the machinery is comparatively cheap and inexpensive to keep up.

(3) That, although the sugar is of a low grade, yet it is saleable at a fixed ratio of price and, therefore, owing to the high price the molasses command, it is more profitable to the planter in these islands to make muscovado sugar under present circumstances than it would be to erect central factories.

The first argument is not of material importance, the local conditions referred to being more of the nature of hindrances to the adoption of new methods than arguments in favour of the old.* They are chiefly due to want of reliable information as to the relative merits of the two processes, and to an unprogressive policy among the planting community in the past. It will be as well, however, to note them before proceeding further. They are briefly :—

(*a*) The small size of the estates.

(*b*) Want of reliable data.

(*c*) The only vacuum-pan factories which have come under the direct notice of the local planters have been small ones, which have not been successful.

(*a*) and (*b*) have undoubtedly been great obstacles in the way of the adoption of central factories, because, for the erection of a central factory, it is necessary for several estates to combine, discard all existing machinery and invest their

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* *Report of Royal Commission*, 1897. App. C., part iii, p. 153; part xi, p. 157.

capital in a costly factory of a type such as all local sugar makers are unfamiliar with.*

With regard to (c) it is interesting to note the explanation given for the want of success of these small vacuum-pan factories, none of which, it should be noted, possess triple-effect machinery. In a report on central factories drawn up by a Committee of the Barbados House of Assembly in 1895, it is stated :—

'Some few owners have gone a small part of the way (towards the erection of central factories) by the erection of vacuum pans and have met with some degree of success ; but these pans have been managed in no scientific manner, and no attempt has been made to obtain from them the most and best work possible. No attempt has been made at double crushing, which is claimed to give some 20 per cent. more juice from the cane. No system of weighing and testing all the cane to find out the loss sustained in manufacture has been adopted.'

The second argument can best be illustrated by figures. The cost of a 300-ton muscovado factory is roughly £3,000 : that of a 3,000-ton vacuum-pan central factory about £40,000, i.e., £25,000 for machinery and £15,000 for buildings, etc. The wear and tear of machinery is much less in a muscovado factory than in an up-to-date central factory, so that where 4 per cent. on the cost of the machinery is charged for maintenance of machinery in the central factory, it is only necessary to charge 2 per cent. in the muscovado ; that is, 4*s.* per ton of sugar made in the muscovado factory, and 6*s.* 8*d.* per ton in the central factory. Owing to the large outlay of capital, annual charges must also be made against the central factory for interest and sinking fund, say, at 5 per cent. and 4 per cent., respectively, on the total capital sunk in the factory, making 10*s.* 8*d.* and 13*s.* 4*d.* per ton of sugar produced.

The muscovado process is simple and easily understood and so does not require as large an expert staff as is necessary in an up-to-date central factory with its intricate machinery ; but although this is the case, the 'expert' wage bill of the central factory is less per ton of sugar produced than that of the muscovado factory, viz. :—

Muscovado.		*Central Factory.*	
One Manager	£150	Factory Manager ...	£400
One Overseer, Accountant, etc.	90	Engineer	250
		Chemist	200
		Overseers, Accountant, etc. ...	320
	£240		£1,170
16*s.* per ton of sugar produced.		7*s.* 10*d.* per ton of sugar produced.	

So far, the expenses per ton of sugar are less in the muscovado factory than in the central factory, but owing to the imperfect crushing in the small mills of the muscovado factories, there is a considerable quantity of the juice wasted, and it is

*Dr. Watts' Report on Sugar Industry in Antigua, 1896.

not unusual that such mills should yield only from 50 to 60 per cent. of the weight of the cane in the form of juice, whereas 72 per cent. ought to be obtained by the mills of large factories. This is a serious loss, and is only slightly compensated by the juice obtained by the higher pressure being slightly less rich in sugar. The actual loss is more apparent when we compare the quantity of canes required to produce a ton of sugar by the two processes as shown in the accompanying table, taken from some figures drawn up by Dr. Watts in December 1902:—

Pounds of cane sugar per Imperial gallon of juice	1·80
Total solids	2·045
Purity	88 per cent.
Specific gravity $\frac{30^\circ}{16·6^\circ}$ C. ...	1·0748

	Muscovado.	*Central Factory.*
Crushing by mill, per cent.	55	70
Extraction, per cent. ...	78	88
Gallons of juice, per ton of sugar ...	1,595	1,414
Tons of cane, per ton of sugar ...	13·91	9·69

By the above calculation, under present conditions it takes 13·91 tons of cane to produce 1 ton of muscovado sugar where it takes 9·69 tons to produce 1 ton of vacuum-pan sugar.

It is interesting to compare this estimate with the results obtained in central factories in other sugar-making countries.

In Egypt about 10 tons of canes yield 1 ton of sugar.*

In Queensland practically 9 tons of canes yield 1 ton of sugar.

In Demerara practically 11 tons of canes yield 1 ton of sugar.

In Trinidad about 10½ tons of canes yield 1 ton of sugar.

In Hawaii 7½ to 8½ tons of canes yield 1 ton of sugar.†

As the canes grown in Barbados and the Leeward Islands compare for richness in juice most favourably with those grown in Hawaii,‡ the estimate of 9·69 tons of canes to 1 ton of sugar should be fairly accurate, but in order to be on the safe side, 10 tons of canes have been reckoned in the following calculations as necessary to produce 1 ton of sugar.

The cost of growing a ton of canes and bringing them to the factory (including upkeep of stock) on a muscovado estate is about 7*s.* 0*d.* The cost of canes to a central factory, buying canes on a sliding scale calculated at the market rate of 4½ lb. of 96° dark crystals, f. o. b. West Indies, for every

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* *Report of Royal Commission*, 1897. App. C., part xi, p. 157.

† *Report of Committee on Central Factories*, Barbados ; 1895, p. 3.

‡ Ibid, p. 3.

100 lb. of canes delivered at the factory, would be 8s. 3·90d. (say, 8s. 4d.) per ton of canes when the f. o. b. value of 96° crystals is £9 5s. per ton. The cost of canes per ton of sugar made will therefore be £4 18s. 8d. in the case of the muscovado factory, and £4 3s. 4d. in the case of the central factory, supposing 14 tons of canes to be required to produce 1 ton of sugar in the former, and 10 tons in the latter.

The cost of manufacture,* including labour, fuel, transport of canes to the factory, bags, stores, chemicals, and transport of sugar to the wharf, if the factory is within a few miles of the port, should not exceed 30s. per ton of sugar made in a central factory with green-megass burners requiring practically no coal. The cost of manufacture in a muscovado factory is about £1 16s. 10d. per ton of sugar made. There are also other annual expenses such as taxes, insurance, etc., amounting to £1 per ton of sugar in the case of the muscovado estate, and 2s. 10d. in the case of the central factory. (See pp. 207 and 209.)

The total cost of production in the two cases per ton of sugar, as calculated here, is as follows :—

	Muscovado.			*Central Factory.*		
	£	s.	d.	£	s.	d.
Maintenance		4	0		6	8
Interest		10	0		13	4
Staff		16	0		7	10
Canes	4	18	6	4	3	4
Manufacture	1	16	10	1	10	0
Sundries	1	0	0		2	10
	£9	5	4	£7	4	0

The actual cost of production *per ton of sugar* is therefore considerably less in the central factory than on the muscovado estate. This is not disputed, but what the advocates of the muscovado process maintain is that, although the actual cost of production is greater per ton of sugar, the muscovado molasses are much richer and more valuable and more than compensate for the loss per ton of sugar.

This is argument (3), and in order to deal fully with it, it will be necessary to consider the argument under two headings :

(a) the value of the sugar, present and future.

(b) the value of the molasses, present and future.

Muscovado is a low-grade, raw sugar seldom polarizing more than 89° to 90° and sometimes as low as 83°. This variation in quality is one of the greatest defects of the muscovado process, the crude method of manufacture preventing anyone being able to rely on producing a sugar of a certain grade, as it not unfrequently happens that the sugar is damaged in the process of manufacture.†

* *Report of Royal Commission*, 1897. App. C., part i, p. 183.
Report of Committee on Central Factories, Barbados ; 1895, p. 8.
† *Report of Royal Commission*, 1897. App. C., part xi, p. 156.

For some years past practically no muscovado sugar has found its way to the English market, with the exception of a relatively small amount of an especially good quality for grocery purposes and perhaps for biscuit and chocolate making. Almost the entire crop has gone to the United States and Canada, but the United States market is being gradually closed against West Indian sugar, and the consumption of sugar in Canada does not at present exceed 170,000 tons, so that West Indian sugar makers will have to turn to Great Britain for a market for their surplus sugar, where, now that bounties are abolished, they will be able to compete with continental beet sugar on equal terms. But while it is confidently expected that West Indian crystal sugars will soon establish themselves in the British market, there are many people who entertain grave doubts as to the future of muscovado sugars. It is stated that the market for it is uncertain; that, while low tests (83° to 86°) will be acceptable to makers of brewing sugar, 87° to 92° tests will not find a ready market among refiners, who prefer crystal sugars; and further, that with a long sea voyage and the difficulties of handling in British ports, muscovado sugar is at a disadvantage as compared with crystals.

The first objection, viz., that the market is uncertain, assumes that muscovado sugar is an article quite apart from dark crystals and 88 per cent. beet; that it is not in the same general demand for refining purposes, if in demand at all; and that it is only bought when other sugars are unobtainable. This I believe not to be the case. Most refiners will buy muscovado sugar at a certain ratio of price according to the purity of the sugar, even if sufficient crystals are made to supply the world's demand for sugar for refining purposes. This ratio is roughly as follows: if 88 per cent. beet (i.e., beet sugar polarizing about 94° which gives a net analysis of 88 per cent.) is 8*s.* 6*d.* per cwt. (cost, freight and insurance), 96° dark crystals will be worth 9*s.* per cwt., and 89° muscovado 8*s.* per cwt. There seems to be no doubt whatever that there will always be a market in the United Kingdom (so long as sugar refining is carried on there) for muscovado at this ratio of price; but at the same time it must be borne in mind that even if the production of muscovado decreases, there is no likelihood of the price rising above this ratio, except perhaps with regard to a small quantity for grocery purposes.

We may safely say, then, that 89° muscovado is saleable in the British market within 20*s.* to 25*s.* per ton of the current price of dark crystals. But a mistake must be carefully avoided, which has hitherto led to some confusion in most comparisons between central factory and muscovado methods. Muscovado sugars have been dealt with as if they always polarized 89°, and central factory crystals (1st. sugars) 96°. The latter is true, but the former is not, owing to the imperfections of the muscovado process. The lower-test muscovado sugars rapidly diminish in value, e.g., when the market price of 89° muscovado is £7 10*s.*, an 86° to 87° sugar is worth about £6 17*s.* 6*d.*, and an 83° to 84° about

£5 19*s*. 6*d*. This difference in value and the practical impossibility of any muscovado estate owner being able to say for certain what grade of sugar he is going to produce in any given year must not be lost sight of in reading the comparison given at the end of this memorandum between the expenses and receipts on a muscovado estate producing an 89 per cent. sugar and in a central factory producing 96 per cent. crystals.

With regard to the second objection, the long sea voyage is undoubtedly a drawback, for, owing to its moist nature, muscovado sugar would in all probability lose not less than 5 per cent. of its weight by draining during the voyage. But with proper precautions, there should be no difficulty as to handling in British ports, as all sugars can be sold ex ship without any handling or landing charges.

What the future of the sugar industry will be it is impossible to prophesy with any degree of accuracy, but an estimate of the probable price of sugar, when conditions again become normal, can be formed, sufficiently approximate for the purposes of this memorandum.

Owing to the cartel and bounty systems there has been an immense overproduction, resulting in a surplus of about 1,500,000 tons which has to be carried over from year to year ;* and only as this surplus is disposed of can an increase in the present price be looked for. It is hoped that the surplus will be diminished by the increased consumption of sugar on the continent, owing to the lowering of import duties to meet the requirements of the Brussels Convention, and by a decrease in the production of continental beet sugar; but it is not to be expected that the diminution will be anything but very gradual. It is estimated that the increase in the 1903-4 crop is close on 500,000 tons (cane and beet), which will have to be got rid of before there can be any diminution of the existing surplus; but so far as can be judged at present from the continued increase in the consumption of sugar on the continent since September 1 last, it is not unreasonable to expect that the surplus will be disposed of before the 1907 crop is on the market. In the meantime prices must continue below natural cost of production until all the surplus sugar is digested.

When the surplus is disposed of, the price of sugar will depend on the natural cost of production—that is to say, as conditions are at present, on the cost of production of 88 per cent. beet, on which the price of other sugars is based. Beet sugar costs on the average about £9 per ton to produce, f.o.b. Hamburg, which, plus 5*s*. freight to England, makes the cost of delivery in England, less duty, £9 5*s*., requiring a selling price of about £10 per ton to give a fair profit. At the ratio of price mentioned above, dark crystals will be worth, f.o.b. West Indies, £9 5*s*., i.e., £10 plus 10*s*. (for higher test) minus 25*s*. (cost of freight and insurance); and 89 per cent. muscovado £7 15*s*. 6*d*., i.e., £10 minus 10*s*. (for lower test) minus 9*s*. 6*d*. (5 per cent. loss by drainage) minus 25*s*. (cost of freight and insurance) :—show-

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* *West India Committee Circular*, Vol. XIX, p. 58.

ing an advantage of about £1 9*s.* 6*d.* per ton of sugar in favour of the central factory process.

The value of the molasses on which the muscovado industry so largely depends is about 6*d.* per gallon (including package).* There are usually about 80 gallons to every ton of muscovado sugar produced, making the value of molasses per ton of sugar £2, and the total value of a ton of muscovado sugar and molasses, f.o.b. West Indies, £9 15*s.* 6*d.*, as compared with £9 5*s.* for a ton of dark crystals and its molasses; an advantage of 10*s.* 6*d.* in favour of the muscovado process. But the cost of producing a ton of muscovado and its molasses has been shown to be £2 1*s.* 4*d.* more than the cost of a ton of dark crystals and its molasses, leaving a balance of £1 10*s.* 10*d.* per ton of sugar produced in favour of the central factory. With sugar and muscovado molasses at the price mentioned, both processes show a fair profit per ton of sugar, i.e., 10*s.* 2*d.* per ton of muscovado sugar, supposing only 89° sugar to be produced, and £2 1*s.* 0*d.* per ton of dark crystals.

It will, however, be observed that, while both processes show a profit, the muscovado estate is largely dependent on the value of the molasses and would be seriously affected by a fall in the price of that article, whereas the central factory is not in the least dependent on its molasses, which are usually of small value. The advocates of the muscovado industry are confident that the present price of molasses will at any rate continue, if it does not increase; they argue that muscovado sugar, or at any rate molasses, must increase in value as muscovado works decrease in number, a decrease which is steadily going on owing to the erection of central factories in Porto Rico, Louisiana, and elsewhere. If this argument is correct, no doubt the owners of muscovado estates would be justified and even right in continuing their present method of manufacture; but it assumes two things:—

(1) That the demand for molasses will not decrease, even if it does not increase.

(2) That molasses produced by the muscovado process have a monopoly of the molasses market; or, in other words, molasses, or, at any rate, good molasses, cannot be produced by any other process to compete successfully with the muscovado product.

First, as to the demand for molasses. Is it a steady demand or is it liable to fluctuations?

In the past we know there have been serious fluctuations; but suppose these to have been due to overproduction; is the future market likely to be a steady one, even with the diminished supply? There seem to be no data on which to base an opinion. Molasses are not a staple article of consumption (except perhaps among certain classes in Canada and Newfoundland), nor are they in demand as raw material for any article of manufacture commanding a ready market. They must therefore depend for their market on popular taste, and

* In Barbados 100 gallons are usually obtained.

their price must in consequence be liable to fluctuations, although perhaps not sufficiently great to cause serious losses: that is if assumption (2) is correct. But is it? Has the muscovado industry a monopoly of the molasses trade? There is every indication that it has not. Already there are mixtures on the market composed partly of molasses and partly of glucose syrup made from Indian corn which are repeatedly sold as bona fide molasses, and in the New York market, at any rate, it is already recognized that the price of molasses depends in a great measure on the American corn crop; for if the corn crop is good and glucose is cheap, the mixture referred to will be largely substituted for pure molasses.*

Such mixtures must tend to keep down the price of ordinary molasses. But even allowing that they will not affect the price of best molasses, it does not seem likely that muscovado estates will have a monopoly of this class of molasses, for there is nothing to prevent their being made equally well in modern factories if sufficient inducement existed, as has been clearly pointed out by Sir Daniel Morris in the pamphlet *Barbados and Porto Rico Molasses*, 1903, p. 30, in which he wrote: 'On estates where vacuum pans are in use, we are of opinion an excellent table syrup could be produced by decolourizing the cane juice with sulphur fumes, then adding lime nearly to neutrality, evaporating the juice in the tayches to thin syrup, adding, if necessary, some citric acid, settling the syrup to allow the impurities to subside, and afterwards concentrating it in the vacuum pan. Syrup made this way should be of a nice golden colour and worth as much as the best Porto Rico "Fancy" molasses. A similar process would be applicable also in the case of central factories. In addition a properly equipped factory would recover at least 25 per cent. more of the saccharose in the canes that is now lost.'

Dependence, therefore, on the price of its molasses for a profit must make the muscovado industry liable to serious ups and downs, and the financial position of a muscovado estate far less secure than that of a central factory producing a staple article of consumption. But while considering this argument as a serious one against the muscovado process, I have no intention of asserting that there is likely to be a serious fall in the price of molasses—in fact, I think it very unlikely; but, on the other hand, I do not think there will be a considerable rise. What I want to point out is that for an industry to depend for a profit on a certain commodity commanding a good price, for which there is not a general demand, is to render that industry speculative and therefore unsound.

We are now in a position to sum up the advantages and disadvantages of the two systems.

Considered in the abstract, a muscovado estate cannot compete successfully with a central factory. It is contrary to all theories of political economy that a small estate, or a number of small individual estates, can compete successfully

* *Barbados and Porto Rico Molasses*, Pamphlet Series No. 28, Imperial Department of Agriculture, p. 24.

with a large one. It stands to reason that a capital of a million in the hands of a single company or individual has far greater competitive force than if it were divided up amongst several individuals. In other words, mere aggregate wealth cannot compete with concentrated wealth, i.e., twenty small estates cannot compete against one large one. The competitive power of the large estate must be and is far greater than that of the small ones.

The argument for the muscovado process does not improve much when considered from a practical point of view. We have seen that, while cultivation is carried on generally in a most careful and up-to-date manner, the method of manufacture on the muscovado estates is antiquated and imperfect, presenting a strong argument in favour of central factories, since it shows that it is better to separate the 'milling' part of the business from the 'agricultural,' for a man is seldom an equally efficient cultivator and manufacturer. But apart from this, we find that the cost of production of a ton of muscovado sugar and accompanying molasses is £2 1*s.* 4*d.* more than that of a ton of dark crystals and its molasses; and that the sugar produced varies so much in the case of the muscovado process that it is almost impossible to draw a comparison between the two kinds; and that even if we compare the value of 89° muscovado, and its molasses under most favourable circumstances with that of 96° dark crystals, there remains a considerable balance in favour of the latter, after the difference in cost of production has been deducted.

In order to illustrate more clearly and more in detail the relative value of the two processes, I append figures showing the expenses and receipts of a muscovado estate producing 300 tons of sugar per annum, and of a central factory producing 3,000 tons of dark crystals per annum.

Owing to the fact that conditions of cultivation and manufacture vary in every island and on almost every estate, it is impossible to illustrate the value of the two processes by merely giving figures of two existing estates, so it has been found necessary to assume that the estates, the expenses and receipts of which are here compared, are situated in an island where conditions of labour, soil, etc., are identical. It will be readily seen that this is absolutely necessary, if a comparison is to be drawn between the two processes which will truly set forth their relative merits. The figures here given are arrived at by taking the average of several estates, the working expenses of which have been kindly placed at my disposal; and the figures themselves have also been approved and corrected by several leading West Indian merchants and estate owners, so that they are as nearly accurate as it is possible to make them.

The figures refer to:—

(1) A muscovado estate producing 300 tons of sugar and 24,000 gallons molasses, and having 122 acres plant canes and 110 acres 1st. ratoons.

(2) A central factory producing 3,000 tons of dark crystals per annum and buying canes from neighbouring estates on a sliding scale calculated at the market rate of 4½ lb.

of 96° dark crystals, f.o.b. West Indies, for every 100 lb. of canes delivered at the factory, at 10 tons of canes to 1 ton of sugar.

(1) Cost of cultivation per acre on the muscovado estate.

(a) *Detailed cost per acre of 122 acres of plant canes: 20 tons of canes to the acre.*

	£	s.	d.
Cleaning and ranging for plough		2	0
Ploughing		5	0
Forking		9	0
Digging cane holes, etc.		10	0
Cutting, carting and dressing plants, planting and supplying		13	2
Weeding	1	15	0
2 cwt. of chemical manure at 11s. on field, and 300 cubic feet of pen manure	1	17	6
Applying manure		4	0
Cutting and tying 20 tons of canes at $4\frac{1}{2}d.$ ...		7	6
Heading out ditto at $2\frac{1}{4}d.$		3	9
Loading carts ditto at $1\frac{1}{3}d.$		2	2
	£6	9	1

(b) *Detailed cost of 110 acres of 1st. ratoons per acre, 16 tons of canes to the acre.*

	£	s.	d.
Cleaning and ranging trash		1	4
Manure	1	5	0
Forking banks		2	9
Applying manure		2	6
Weeding		15	0
Cutting and tying 16 tons of canes at 5*d.*		6	8
Heading out 16 tons of canes at $2\frac{1}{2}d.$		3	4
Loading carts, 16 tons of canes at $1\frac{1}{3}d.$		1	9
Carting canes, 16 tons at 2*d.*		2	8
	£3	1	0

Total cost of cultivation.

	£	s.	d.
122 acres at £6 9*s.* 1*d.* per acre =	£784	7	2
110 acres at £3 1*s.* 0*d.* per acre =	£335	10	0
	£1,122	18	2

EXPENSES AND RECEIPTS.

Expenses.

	£
(a) Staff:	
Manager	150
Overseer	90
(b) Taxes	85
(c) Insurance	45
(d) Interest at 5 per cent.	150
(e) Estate upkeep:	
Repairs of officers' and labourers' houses, bridges over drains, clearing water-courses, digging out bush	120

(f) General charges: Legal, telephone, cablegrams, bank charges, etc.	£ 50
(g) 2 per cent. depreciation on machinery value £3,000	60
(h) Cost of cultivation	1,122
(i) Upkeep of stock	357
Manufacture: 122 acres at 20 tons: 110 acres at 16 tons: will yield 4,200 tons of canes; 4,200 tons of canes at 14 tons to the ton of sugar will yield 300 tons of sugar and 24,000 gallons of molasses. Cost at £1 16*s.* 10*d.* per ton of sugar and its molasses	552

Summary of estate expenses.

(a) Staff	£ 240
(b) Taxes	85
(c) Insurance	45
(d) Interest	150
(e) Estate upkeep	120
(f) General charges	50
(g) 2 per cent. depreciation...	60
(h) Cultivation	1,120
(i) Stock	357
(j) Manufacture	552
	£2,779

Cost of production per ton of sugar ... £9 5*s.* 6*d.*

Receipts.

300 tons of 89 per cent. muscovado at £7 15*s.* 6*d.* per ton, f.o.b. West Indies	£2,332
24,000 gallons of molasses at 6*d.*	600
	£2,932

Profit to the estate £153
Profit per ton of sugar ... ... 10*s.* 2*d.*

(2) (a) Expenses and receipts of a central factory producing 3,000 tons of dark crystals per annum, and buying canes from neighbouring estates on a sliding scale calculated at the market rate of $4\frac{1}{4}$ lb. of 96° dark crystals, f.o.b. West Indies, for every 100 lb. of canes delivered at the factory.

Expenses.

(a) Staff:

Factory Manager	£ 400
Engineer	250
Chemist	200
Overseers, Accountant, etc.	320
	£1,170

(b) Insurance	£ 280
(c) 4 per cent. on £25,000 for maintenance of machinery	1,000
(d) 5 per cent. interest on capital of £40,000 ..	2,000
(e) 27,000 tons of canes at 8*s.* 4*d.* per ton i.e., 10 tons of canes to 1 ton of sugar ...	12,500
(f) Upkeep of stock	150
(g) Cost of manufacturing 3,000 tons of sugar at £1 10*s.* per ton	4,500

Summary of expenses.

(a) Staff	£ 1,170
(b) Insurance	280
(c) Maintenance	1,000
(d) Interest	2,000
(e) Canes	12,500
(f) Stock	150
(g) Manufacture	4,500
	£21,600

Cost of production per ton of sugar ... £7 4*s.*

Receipts.

3,000 tons of 96° crystal sugar at £9 5*s.* per ton £27,750

(Note.—A portion of the sugar will be 2nd. quality, and the loss on that compared with the 1st. quality will be balanced by the proceeds of the molasses.)

Profit to the factory after paying 5 per cent. interest on capital £6,150

Profit per ton of sugar ... ... £2 1*s.*

Summary.

	£	*s.*	*d.*
(1) Muscovado estate profit per ton of sugar		10	2
(2) Central factory (10 tons of canes to 1 ton of sugar) profit per ton of sugar	£2	1	0

It will be noticed that the comparisons have been made on the supposition that all sugar produced on the estates mentioned is sent to the English market. This has been done because the price of continental beet sugar must control the price of West Indian sugar for some time to come, and also because it is easier to calculate the ratio of price between the different sugars in the British market, where the consumption of sugar is very great, than in the Canadian market where it is small. The fact that the greater, and an increasingly greater, proportion of West Indian sugar will now go to Canada does not affect the value of these comparisons; the controlling factor (continental beet sugar) is the same in each case, the only difference being that West Indian sugar makers sending their sugar to Canada have the advantage of the $33\frac{1}{3}$ per cent. preference granted to West Indian sugars by the

Dominion Government, and also of the amount by which the freight from Hamburg to Canadian ports exceeds that from the West Indies to Canadian ports.

It is not likely that any United States or Cuban sugar will compete with West Indian sugar in the Canadian market, as the United States and its dependencies barely produce enough for home consumption; nevertheless it does not seem likely that West Indian sugar makers will obtain a much higher price, f. o. b. West Indies, for the sugar sent to the Canadian market, than for the sugar sent to the British market, because until Canada can take all the West Indian sugar, there must be keen competition among West Indian producers for the Canadian market, which will probably be sufficient to keep the price obtainable, f. o. b. West Indies, for the sugar sent there, down to, or very little above, the price obtained for sugar sent to the British market. The reason for this is obvious: Canada can only take a proportion of the West Indian sugar crop, whereas Great Britain can take it all; the West Indian producers have only these two markets where they can send their sugar, so that the price obtainable in the British market must control the price of West Indian sugar in the Canadian market.

NOTE ADDED:—

The writer desires it to be clearly understood that in making comparisons between the industries he has dealt with the muscovado industry at its best, and under circumstances where a good quality of sugar is made. There are many cases where the mills are old and ineffective, and others where inferior sugar is made. Had these been taken into account, the comparisons would have been more favourable to the modern factory.

EXTRACTION AND PREPARATION OF RUBBER.

Though the experimental planting of rubber-yielding trees has been carried on, with a considerable measure of success, in several of the West India Islands, little has, so far, been done in the systematic starting of rubber plantations on a large scale. At the West Indian Agricultural Conference of 1901, Mr. J. H. Hart, F.L.S., read an interesting paper on 'Rubber Planting in the West Indies', which was published in the *West Indian Bulletin* (Vol. II, pp. 100-13), in which the prospects of rubber planting in Trinidad and Tobago were fully dealt with. It was shown that rubber trees, especially Castilloa, thrive in the West Indies. The Castilloa tree has also been proved to be well adapted to shading cacao. It would appear that rubber planting, whether separately or as an adjunct to cacao cultivation, offers fair hope of success.

It is advisable that planters should be supplied with reliable information as to the extraction and preparation of

rubber, and with that object the following article, dealing with the tapping of the trees and the preparation of the product for the market, has been prepared.

AGE FOR TAPPING RUBBER TREES.

The present knowledge of the earliest age at which Castilloa trees may be tapped with safety is far from satisfactory, and opinions on this point differ considerably. As Cook* says, 'careful experiments may be necessary to determine whether, e.g., the taking of ½ lb. of rubber from each tree in the sixth year will retard growth so as to diminish the yield of succeeding years.' It would appear that, so far, the only consideration in determining this has been the quality of the rubber, since the rubber obtained from young trees is of inferior quality, containing a larger per cent. of resinous matter.

Dr. C. O. Weber, in his 'Journey to a Rubber Plantation on the Isthmus of Columbia,'‡ points out that there is a decrease in the amount of resin as the trees get older, as is shown by the following figures:—

Resins in Rubber from Trees.

2 years old	... ...	42·33 per cent.
3 ,, ,,	... ...	35·02 ,, ,,
4 ,, ,,	... ...	26·47 ,, ,,
5 ,, ,,	... ...	18·18 ,, ,,
7 ,, ,,	... ...	11·59 ,, ,,
8 ,, ,,	... ...	7·21 ,, ,,

'It will therefore be seen that my advice not to tap the trees until they are at least eight years old is not only justified in the interest of the life of the trees, but also in the amount of resin which may safely be admitted in rubber of high quality.

'The rubber from the six-year-old tree was very resinous, but otherwise fairly good. The rubber from the seven-year-old tree was of very fair quality indeed, and that of the eight and eleven-year-old trees excellent in every respect. It would, therefore, appear inadvisable to tap the trees before they are eight years of age.'

It will be seen that similar conclusions have been reached in Trinidad (p. 221).

With regard to the age at which Para rubber trees should be tapped, we cannot do better than to quote the following paragraph from *Circular* No. 4 (p. 29) of the Royal Botanic Gardens, Ceylon:—

'The yield of rubber from very young or slender trees is too small to make their tapping worth while, and it is best for many reasons to abstain from tapping a tree until it has reached a girth of 2 feet. In a large plantation the girth of the trees always varies between wide limits. A few trees may be fit to tap after the sixth year, and in every subsequent year

* *The Culture of the Central American Rubber Tree.* Bulletin No. 49, Bureau of Plant Industry, U.S. Department of Agriculture.

‡ *India Rubber and Gutta Percha Trades Journal*, September 29, 1902.

more and more trees will reach the size necessary. In favourable localities the bulk of the trees should be in bearing before the end of the eleventh year. The results of the experiments hitherto made at Heneratgoda go to show that it is inadvisable, having regard to the future, to tap trees of less than 2 feet in girth, but it is still an open question whether the minimum size of the tree for tapping should not be fixed even higher. This, however, would, of course necessitate longer waiting for the return, as the mean rate of increase of girth in trees of this size is only about 3 inches per annum.'

TAPPING.

It has for some time been recognized that the crude methods employed by the natives in different countries in which rubber trees are found are not calculated to preserve the life of the trees and consequently need much improvement. The tool usually employed is the 'machette,' and the gashes made with this tool not only seriously affect the life of the tree, but also cause a deterioration in the quality of the product on account of the inevitable admixture of foreign matter.

As Dr. Weber states, then, 'the first consideration is not only to conduct the tapping in such a way as to preserve the life of the tree, but even to prevent this operation from injuring its vigour and growth.' In deciding upon the most satisfactory method of tapping the trees, the position, distribution, and arrangement of the laticiferous vessels in the tree must first be taken into consideration. Dr. Weber's observations on this point are of interest:—

'A microscopic examination of longitudinal sections of the bast layer of Castilloa at once revealed the fact that, while this layer contains an enormous number of milk-ducts running longitudinally through the tissue, there is surprisingly little evidence of lateral intercommunication (*anastomose*) between them. In exact agreement with this observation is the fact that longitudinal incisions produced an absurdly small flow of latex, indeed, in many cases none at all; this for the simple reason that the number of milk-ducts opened by a vertical incision is, in the absence of horizontal branchings, simply the number of milk-ducts occupying the width of the cut in the horizontal direction. Compared with the total number of milk-ducts in the layer of bast surrounding the cambium, the former number is, of course, insignificantly small. Moreover, we must bear in mind that the latex is held in the milk-ducts by capillary force, and in order to obtain a flow of it from any incision, we largely depend upon the pressure exerted upon these milk-ducts by the turgescence of the cellulose tissues of the tree. It will readily be seen that a vertical incision largely relieves this pressure, and consequently the flow of latex obtainable by such an incision will not even be proportional to the number of milk-ducts, however small, which have been cut into.

'*Horizontal Cuts.*—On the other hand, very little reflection will show that, in applying a horizontal incision, not only do we

open all the milk-ducts running through the area defined by that incision, but, moreover, the pressure due to the above-mentioned turgescence is not in the least interfered with and assists materially in producing a most copious flow of latex. It would, therefore, appear to follow that, while vertical cuts are entirely useless, at any rate as far as *Castilloa elastica* is concerned, horizontal cuts produce the maximum flow of latex, and a system of horizontal cuts therefore offers the best prospects for an effectual tapping of the trees. This no doubt is so, but the circumstance must not be overlooked, that a horizontal cut is not very satisfactory for the gathering up of the exuding latex, this particularly in conjunction with the fact that a Castilloa tree cannot be drained by a small horizontal cut, as is, for instance, the case with Hevea, but requires a whole series of cuts. This renders it desirable that, instead of tapping Castilloa with a number of small cuts, a continuous cut should be adopted, and one which drains practically the whole area of the trunk. There is only one cut of this description, and this is the one known as the spiral cut, which indeed has always been largely employed by the native collectors exploiting Castilloa trees. I have, indeed, satisfied myself that the flow of latex obtainable from a spiral cut applied at an angle of not more than 45° produces excellent results as far as the flow of latex is concerned.

'There is also the repeatedly advocated system of an ascending series of V-shaped cuts, the apices of which are connected by a vertical cut, which serves as a channel down which the milk is enabled to flow. In the first instance, I consider this vertical cut objectionable, as while it defaces the tree, it does not contribute to the yield of latex obtained. Moreover, in the case of Castilloa trees at Las Cascadas this vertical cut would be quite useless, as the latex yielded by the trees issues from the cuts as a thick cream which does not flow, so that in this case the V-shaped cuts would only have about the effect of a double system of crossing spiral cuts.'

This matter is dealt with very clearly in the *Circulars* of the Royal Botanic Gardens, Ceylon (Series 1, Nos. 12, 13, 14, pp. 119-21), as follows:—

'In order to obtain the latex from the trunk of a rubber tree the laticiferous ducts have to be cut in some way or other. The question naturally arises as to what is the best kind of wound to make in order to extract the maximum amount of latex with the minimum of injury to the tree. Since the milk tubes situated in the inner bark (bast) run for the most part longitudinally, it stands to reason that an incision made horizontally will yield more latex than a similar one made vertically, because a greater number of tubes will be severed in the first case than in the second. An oblique incision is, however, on the whole, preferable to a truly horizontal one, for the milk stream is directed to one point—the lower end of the incision—whereas in the transverse cut the milk is apt to trickle from more than one point, usually from the two ends. Whether the latex be collected from each incision separately—the best plan if it flows at all freely—or whether it be collected at the base of the tree from the streams coming from a number of vertical

rows of incisions, the inclined incisions leave less latex to dry on the tree than the horizontal ones, for, as a rule, in the one case the latex oozes out in a single stream, whereas in the second case it makes two streams—that is on the assumption that the amount of latex flowing out of each kind of incision is the same.

'The two following experiments on *Hevea brasiliensis* illustrate the differences between the amount of latex collected from vertical, horizontal, and oblique incisions:—

(1)	21 vertical	incisions gave	8·5	c.c. latex.	
	21 oblique	„ „	16·5	„	„
(2)	14 horizontal	„ „	6·0	„	„
	14 oblique	„ „	12·0	„	„

'In both cases the oblique incision yields about double that of the other. There seems little difference between the amount collectable from a vertical and a horizontal incision. Although there is a greater output of latex from the horizontal cut, yet much more dries on the wound than in the case of the vertical, consequently the amount which drops into the receiver comes to about the same in the two cases.'

The writer of this article goes on to say that, having assumed that the oblique incision is the best, the next point to consider was whether it should be double or single. A double incision made in the form of an upright V has been largely employed. 'Experiments on the relative quantity of latex collectable from single oblique incisions and from double ones, in the form of a V, have shown that for Heveas growing at Peradeniya and Heneratgoda, the latter yield usually about double the amount that the former do, but not always.' The experiments pointed to the conclusion that 'if the trees run well, very little more latex is obtained by doubling the incision in the form of a V; whereas if the flow is poor, then a V gives about double that of a single oblique cut. . . . The above remarks refer only to Hevea. . . Castilloa, on the other hand, flows as a rule so much more freely from an incision than Hevea, that a V cut is wholly unnecessary.'

TAPPING INSTRUMENTS.

As has been stated, the tool used by the natives is the common 'machette'; frequently these have the point turned up. The objections to this are that, even in the hands of a most dexterous workman, the wound is ragged and a large amount of woody debris is produced. This is one of the principal causes of inferiority in Central American rubber. As a blunt instrument bruises the wood and milk tubes, a keen edge is most essential.

The tool depicted and described on p. 216 appears to have given complete satisfaction in Ceylon. It has also been proved at the Botanic Station at Dominica to be a satisfactory implement for tapping Castilloa trees.

It is frequently advised that a tool for making incisions in rubber trees should possess some arrangement for regulating the depth of the cut in order to prevent the wood from being

injured. Dr. Weber maintains that, praiseworthy as this notion may be, it is nevertheless impracticable on account of the great variation in the thickness of the layer to be cut. Further, he came to the conclusion that cutting the wood of Castilloa trees, although perhaps retarding the healing up of the wounds, did not necessarily injure the trees to any serious extent. Any ill effects were probably due to the fact that such wounds would offer a chance to insects to lay their eggs in the wood: this danger can be effectually guarded against by treating the wounds with some antiseptic paint.

With regard to the instruments for tapping Hevea trees, it is stated in the Ceylon *Circular* already quoted that for most of the experiments an ordinary carpenter's chisel and a mallet were used. The following quotation on this subject is of interest:—

'We should be inclined, on the whole, to recommend an ordinary carpenter's chisel (or perhaps better, a wedge-shaped chisel) with a thickness of $\frac{3}{16}$ to $\frac{1}{4}$ inch (5 to 6 mm.) at a distance of $\frac{1}{2}$ inch (13 mm.) from the cutting edge. The breadth of the chisel may vary from 1 to $1\frac{1}{2}$ inch (25 to 37 mm.). It seems hardly necessary to have a chisel with a guard, for the bark varies somewhat in thickness, both with respect to the age of the tree and to the height of the trunk. Unless the guard were movable, the chisel, being naturally always driven in up to the stopping place, would sometimes penetrate the wood, if the bark happened to be thinner than usual, and if thicker might not reach the innermost milk-ducts—the ones which flow the freest. With care and a little practice, the chisel and mallet can be used so as just to reach the cambium and no further. The blows should be lightly dealt, and stopped as soon as any increase of resistance is felt.

'The above remarks refer chiefly to *Hevea brasiliensis* but apply equally well to *Manihot Glaziovii* and to *Castilloa elastica*. The last mentioned has a much thicker bark, measuring $\frac{3}{4}$ inch, whereas the bark of corresponding Heveas measures $\frac{3}{8}$ inch, just half that of Castilloa.'

The *Straits Times* of April 16, 1903, gives an interesting account of experiments, lasting many months, which had been carried out at the Economical Gardens in regard to the best method of tapping Para rubber trees. It is stated that Mr. A. D. Machado, who had conducted the experiments, had found it possible to tap trees every second day for six months in each year without in the least hurting the tree, or impairing its growth. Mr. Machado's method has been proved to give better results than either the method of making gashes in the bark of the tree, or the method known as the 'herring-bone' system, in vogue on some of the more advanced plantations. This 'herring-bone' system consisted in making a spine or main gash, measuring 8 to 15 inches in length and with a width of $\frac{1}{4}$-$\frac{3}{4}$ inch, into which a large number of contributing minor gashes led. Mr. Machado has demonstrated that the best results are obtained from a series of little incisions measuring 2 inches in length and $\frac{1}{8}$ inch in width. Such small wounds are found to be utterly harmless. Each incision is provided

with a little soldered tin cup, which is thrust into the bark of the tree immediately under the incision, so that the latex runs into it. This method of collecting into a separate vessel the latex exuding from each incision is also recommended by the writer of the Ceylon *Circular* already quoted:—

'We have devised a small tin vessel, which seems to answer very well, and it can be made at a cheap rate and is light in weight. It is half cylindrical in shape, 2 inches long by about 1 inch broad. Near the top of the flat side a small spike is soldered in, which projects about $\frac{3}{16}$ inch outwards. The tin holds about 30 c.c.; as far as our experience goes of yield of Hevea trees in Ceylon, the tin might easily be made a third less in size. The tin is fixed on the bark by pressing in the spike with the thumb. To prevent the latex from trickling down between the bark and the tin, some plastic material is needed to lute the upper edge of the tin to the bark.

'For Castilloa a tin of the same pattern has been used, but about three times the size (100 c.c. capacity) and with a stouter and longer ($\frac{3}{8}$-inch) spike, necessary for pressing into the harder outer bark and for supporting a greater weight. The tins can be fixed some time beforehand. Since tapping is best performed in the early morning, the tins can be luted on the previous evening. For this reason it is perhaps best to have each tin provided with a lid, so as to keep out dirt or rain. The lid should have no downward projection on the straight side, so that it can easily be slipped on or off.'

It is found necessary, in the case of Para rubber trees, to place a little water into each tin, as the latex is liable to dry up. Further, it is necessary that the contents of the tin should be stirred on account of the tendency of the latex to rise to the surface in clots: this is not necessary in tapping Castilloa trees, the latex having no tendency to clot.

It may be of interest to reproduce here an account of methods successfully adopted on a Para rubber estate in Ceylon. This information was contributed to the *India Rubber World* (March 11, 1903) by Mr. Francis J. Holloway and appeared in the *Agricultural News* (Vol. II, p. 265):—

The tool employed for tapping rubber trees on this estate is not equalled by any other in use, for its clean cut and absolutely safe incision, the tree not being damaged in the least. The shape is indicated by the accompanying cut. (Fig. 1.)

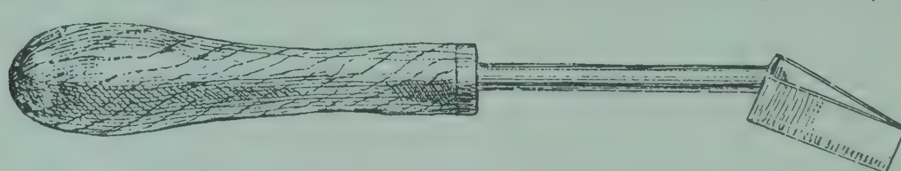

FIG. 1. Tool for incising Rubber Tree. *b.*

In practice both hands are used to hold the wooden handle. Placing the corner of the angle *b* at the start of the cut, the tool is pulled downward two or three times in the same incision, care being taken not to cut into the wood. Though this may seem difficult at the beginning, a little practice will soon make the work easy. After two cuts have been made, converging in the shape of the letter V, another

labourer places a small tin cup at the lower point of the V (fig. 2). Care should be taken that at this point the two cuts do not run together, but that a small space be left between them. The incisions should be about 4 inches long, with a space of at least 3 inches between them at the top. The same space (3 inches) should be left before beginning the next pair of incisions in going around the tree. This is absolutely necessary, for if the cuts join the flow of sap to the tree will cease, and the tree will die. The first series of incisions should be made as far up the tree as a person standing on the ground can reach. Every second day a new band of incisions may be made lower down, as indicated in the drawing (fig. 3). About twenty rings or bands of incisions can be made around a tree within a distance of 6 feet from the ground. About five V-shaped incisions may be made around a tree 40 inches in circumference

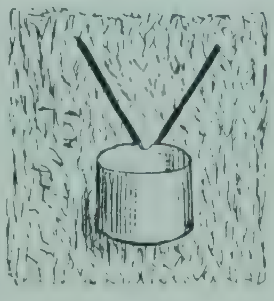

FIG. 2. Incisions with tin attached.

The tin cups used are about 2 inches in diameter and 2 in depth. As the latex flows immediately after the cuts are made, the tapper's assistant at once presses the edge of a tin cup into the bark, no nails or putty or wax being required to hold it in place. A third labourer follows with a pail of water, putting a small quantity into each tin to prevent the latex from coagulating—a very necessary precaution especially on a hot day. The tapping as above described is done early in the morning, and in this way three men can place 400 cups in a half-day, and attend to the rubber obtained.

FIG. 3. Relative Position of Series of Incisions.

The contents of all the tins are stirred once, or oftener; besides which the labourers must see to it that none of them overflow. Work is started about 6 a.m., and by 11 a.m. all the tins have been taken off and emptied into a pail. While one coolie carries the pail of latex to the factory, the others wash out the tins and at once replace them under the same cuts. The tins are again emptied, in the same manner, at 3 p.m., which completes the yield of latex from a given set of incisions. In the meantime, after the tins are washed, the coolies pick off any rubber that may have dried in the wounds made on the last round, which is called 'scrap.'

As the latex is brought to the factory in a liquid state (mixed with water, which is necessary to enable the latex to go through the process by which the rubber is preserved), it is strained through a very fine wire mesh—a milk strainer for example—into shallow tin pans, 7 inches square by 2 inches in depth, in which it is left to stand overnight. By morning the rubber will have coagulated naturally, without the use of any chemicals, and most of the water will have become

separated from the pure rubber. The lump of rubber is then taken out and placed on a table and gently pressed with the hand to exclude the water, after which a wooden roller worked by hand is passed over it, back and forth, until more of the water has been expressed, leaving a flat sheet of rubber about 8 inches square and $\frac{3}{8}$ inch thick. The lumps of rubber thus made are placed on caned trays or frames about 6 x 3 feet, caned like the bottom of a chair, though not so closely woven. After the rubber sheets have remained on the trays for four or five days, they are hung to dry on wires stretched across the room, after which they will require frequent attention to prevent mildew, a man being detailed to rub off all mildew spots with a rag. About two months are required for the rubber to become thoroughly dry and free from white patches. So long as these patches appear, it is an indication of dampness and further drying will be required.

When thoroughly dry, the sheets of rubber are ready for shipment, and are packed in boxes about 18 inches square and 8 inches deep—usually about 50 ℔. to a box. The secret of the high prices obtained for rubber from Ceylon lies (1) in the straining of the latex by which every particle of dirt is kept out, and (2) in the thinness of the sheets of rubber, which permits any one to see that they are free from dirt, sand, etc. No chemicals are used, and no heating is required. On the whole, this is the simplest method, when one knows how, that could possibly be adopted. The rubber from most countries now comes to market in large pieces, and can conceal any amount of impurity, while in other cases the latex is allowed to dry on the stem of the tree and when pulled off contains a large percentage of bark and dirt which means loss to the buyer and extra work in the factory.

The last sales of rubber from this estate have brought probably the highest average price of any rubber sold in the world during the same period, and this is saying a good deal, namely, an average of 3*s.* 11*d.* per ℔. The total output for Ceylon for 1903 will be about 10 tons, of which this estate will send 2 tons.

PREPARATION OF COMMERCIAL RUBBER FROM THE EXTRACTED LATEX.

If Para latex be merely allowed to dry after extraction it is found to undergo putrefaction, and the solid rubber becomes mouldy and of a dark colour. This is due to the presence of a considerable quantity of albuminous matter in solution. In order, therefore, to free the rubber from moisture without putrefaction setting in, it is necessary either to remove the albuminous matter or to add some antiseptic substance that prevents the growth of moulds and bacteria. Mr. R. H. Biffen, who has made a study of this subject, has demonstrated that chemical processes are unnecessary, since the preparation can be effected by a physical process, viz., the use of a modified form of centrifugal milk-tester. By this means a pure rubber can be obtained free from admixture of any proteid matters.

It would appear that the fact that the caoutchouc globules of Castilloa are comparatively large enables the rubber to be

separated much more readily, since if the latex is diluted the globules float on the top to form a kind of cream.

In the case of Castilloa rubber, the next process in the production is that known as 'coagulation.' This coagulation is brought about by the addition of acids or alkalis. Sometimes alum is used, but in British Honduras a decoction of the plant known as 'moon-plant' is more often employed. Dr. (now Sir Daniel) Morris* describes this method as follows:—'At the close of the day the rubber gatherer collects all the milk, washes it by means of water, and leaves it standing till the next morning. He now procures a quantity of the stem of the moon-plant, *Ipomoea Bona-Nox* (Calonyction speciosum), pounds it into a mass, and throws it into a bucket of water. After this decoction has been strained, it is added to the rubber milk, in the proportion of 1 pint to a gallon, or until, after brisk stirring, the whole of the milk is coagulated. The masses of rubber floating on the surface are now gathered from the liquid, kneaded into cakes, and placed under heavy weights to get rid of all water particles. When perfectly drained and dry the rubber cakes are fit for the market and are exported generally in casks.'

The trouble experienced in preparing Castilloa rubber for the market lies in freeing the rubber from albuminous matters.

After a discussion of the methods in vogue for preparing rubber, in which the objections and drawbacks are clearly set forth, Dr. Weber sums up the matter and gives the following description of a process satisfactorily adopted at the Las Cascadas estate:—

'It is now very easy to see that the chief point in attempting to prepare a pure rubber from the latex of *Castilloa elastica*, and as a matter of fact, from the latex of any other rubber tree, must consist in the elimination from the rubber, prior to its "agglutination," of all albuminous matter. The first step in this direction is the diluting of the crude latex with water, of which at least five times the volume of the latex treated should be used. In the case of the thick, curdy latex yielded by the trees at Las Cascadas, it is preferable to use actually boiling water; but in how far this applies to the latex obtained in other districts or from different trees is a matter for experiment. Boiling water at once converts this latex into a thin, very fluid milk, which is strained through a common cotton gauze in order to remove from it any insoluble impurities, such as earth, wood, bark, and the like. This milk is best strained into thoroughly well-washed petroleum barrels. As soon as the barrel is completely filled, about 8 oz. of formaldehyde are added, the whole well stirred, and allowed to stand for twenty-four hours. The action of the formaldehyde appears to be two-fold. In the first instance, it effectually prevents any tendency of the albuminoids to coagulate in the hot solution and therefore to cause mischief. But, as compara-

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**The Colony of British Honduras.* By D. Morris. *London: Edward Stanford, 1883.*

tive experiments showed beyond any doubt, it also has a distinct effect upon the India-rubber, which collects on the top of the washwater in the form of a snow-white cake of rubber of such strength and toughness that it can be lifted out of the barrel in one mass. On cutting this cake open, it will be found that it is rather spongy, being full of little holes which are still filled with some of the albuminous, though very dilute, mother liquor. If, therefore, the rubber were dried in this state, it is obvious that it would still contain a small quantity of the objectionable albuminous matter. For this reason, the rubber contained should at once be taken, cut into strips, and subjected to a thorough washing upon an ordinary rubber-washing machine. As all albuminous matter present is still in a state of perfect solubility, there is no difficulty whatever in completely removing every trace of it by carrying out the washing with a plentiful supply of water on the washing rollers.

'The rubber thus obtained is a product of a degree of purity in which no rubber, not even the finest brands of Para, has ever been offered to the manufacturer. It is absolutely free from solid impurities of any description, it contains no trace of either soluble or insoluble organic or inorganic impurities. Of course it contains a small amount of resinous matter combined with only a trace of the constituents known as "ash."'

Rubber was successfully prepared last year at the Botanic Station at Dominica by the following method, which is a modification of that recommended by Dr. Weber:—

After tapping the trees the latex was caught at once and added to water, to prevent it from coagulating and so becoming common scrap rubber. When all the latex was collected, the whole was passed through cotton gauze to remove all pieces of wood and bark. A small quantity of formalin was then added as a preservative, the milk well stirred and then poured into a wooden vessel and allowed to stand. The rubber, white in colour, slowly rose to the top, and the water, then a black-looking liquid, was run off gradually below. As soon as this black liquid had all drained away, the cake of rubber hardened and rapidly darkened in colour. It could then be handled and thoroughly washed and dried. The whole process occupied from two to three weeks.

The sample of rubber thus prepared was pronounced by Dr. Weber, to whom it was submitted for a report on its commercial value, to be worth from 2*s.* 10*d.* to 2*s.* 11*d.* per ℔. A higher price would have been obtainable had the sample been freer from resins and of a better colour.

A sample of rubber, prepared according to Dr. Weber's method by Mr. J. H. Hart, Superintendent of the Botanical Department, Trinidad, was forwarded to the Imperial Institute for a report as to its quality and value (see p. 222). The sample was of a light-brown colour externally, quite white within, and perfectly dry and free from foreign matter. The rubber was not sticky and was very elastic and tenacious. The

brokers to whom the sample was submitted quoted a price of 2*s.* 9*d.* per ℔.

The ordinary method adopted for preparing Para rubber is by means of a smoke fire. This method is summarized by Sir D. Morris as follows :—

'A large clay stove is used for curing the rubber. A fire is lighted underneath made of the nuts of the Urucuri palm (*Attalea excelsa*). The smoke escapes through an apperture at the top. A heavy paddle is now dipped into a large bowl containing the day's gathering of milk and immediately placed in the smoke. The effect of the heat and smoke is to coagulate the milk and give it a dark colour. The process is repeated until a large cake is formed. The paddle is then released by making a slit on one side.

'According to Mr. Biffen, in the paper already cited, the latex of *Hevea brasiliensis* is alkaline, and the addition of a solution of ammonia preserves it indefinitely from spontaneous coagulation. The coagulation of the latex by exposing it to the smoke of the Urucuri nuts is doubtless brought about partly by heat and partly by the action of the acetic acid contained in it. The latter and the creosote, also present, further tend to preserve the rubber. The smoking process would appear to be applicable only in the case of latex possessing alkaline properties. It is unsuitable in the case of the latex of *Castilloa elastica*, as this has an acid reaction towards litmus paper, hence alkalis are used.'

EXPERIMENTS WITH RUBBER IN TRINIDAD.

For some time Mr. J. H. Hart, F.L.S., Superintendent of the Botanical Department in Trinidad, has carried on a series of experiments with different kinds of rubber-yielding trees in that island. The following extracts are taken from Mr. Hart's annual report for 1902-3 :—

'A trial was made in February of latex from Castilloa and Funtumia. It was found that at four and a half years from planting, Funtumia gave good rubber, while that produced by trees of Castilloa of the same age was evidently immature and of less value. Funtumia latex is more easily coagulated than that of Castilloa, as it can be prepared by heating in vessels over a fire and besides gives a larger percentage of rubber from equal measures of latex. In Castilloa it has been found essential to wash away the albuminoids by creaming before coagulating the rubber, as the presence of the latter tends to spoil the quality of the produce. This fact was pointed out in an article in the Department *Bulletin* in January 1901, in discussing papers on the same subject by Messrs. Biffen and Parkin. The point has recently been confirmed by Dr. Weber's experiments on the Isthmus of Panama. The use of commercial formalin for the purpose of agglutination, or collecting together the rubber globules, as described by Dr. Weber, is instructive, and promises to prove an excellent means of preparing rubber of the best quality from the rubber fluids, or latex, of Castilloa. It has been seen in our experiments,

however, that the actual agglutination of the rubber globules will take place, and the rubber can be removed in whole pieces, without the aid of formalin, if sufficient time is allowed for the coalescence to take place. When formalin is added, however, it acts as a preservative, prevents decomposition, and materially improves the quality of the rubber.

'The question as to the proper season for bleeding Castilloa is one which must be decided generally by the cultivator, but our experience goes to show that it should not be done in the dry season, as the flow of rubber fluids is then sluggish and uncertain, although the latex at such times contains a larger proportion of rubber. It is doubtful, moreover, if it can be manipulated with the same economy as during moist weather, when plant fluids circulate more freely. According to our results, the flow of latex is materially affected by the rainfall. This has been proved by flooding the roots of trees with water, which universally results in a rapid flow of rubber fluids if trees are tapped one or two days after application. If one side of the tree only is flooded, only one side is affected; that is, one portion only of the roots takes up water, which is not equally distributed through the tissues, but to one side of the tree only.'

The *Bulletin of the Imperial Institute* (1903, No. 4) contains a detailed report by Professor Wyndham Dunstan, F.R.S., on samples of Castilloa and Funtumia rubbers prepared in connexion with the experimental cultivation of various rubber-yielding trees in Trinidad. These samples were forwarded to the Imperial Institute with the object of ascertaining by chemical investigation, supplemented by commercial valuation, the influence of the age of the tree on the quality of the rubber it furnishes, and also by the same means to determine the effect of the method of coagulation employed on the quality of the rubber furnished by the latex. The following is a brief summary of this report:—

Two small samples of rubber, prepared respectively from young trees (four years of age) and old trees, were analysed. The analyses confirmed the opinion, based upon the appearance of the samples, that rubber prepared from young trees of *Castilloa elastica* is a very inferior product, consisting largely of resin, and show clearly that Castilloa trees four and a half years old will not yield a marketable rubber.

An examination of two small samples of rubber, derived respectively from *Funtumia africana* and *Funtumia elastica*, showed that there is a great difference in the quality of the rubber yielded by the two species. The former was found to be much inferior, containing nearly four times as much resin and only half as much caoutchouc as the latter. The samples were obtained from seedlings of the two species of the same age, viz., three years, and with stems about 3 inches in diameter.

The two samples of Castilloa rubber from trees twelve years old and upwards were of much better quality than those from younger trees, though the amount of resin present, 13·8 and 8·3 per cent., respectively, is still higher than is usually found in

the best qualities of this variety of rubber. These two samples were valued at from 2*s*. 4*d*. to 2*s*. 9*d*. per lb.

Two samples of rubber from *Funtumia elastica* were also forwarded. They were derived from trees of the same age, viz., four and a half years old, the only difference being in the method of coagulation employed. Sample A had been coagulated with alcohol: sample B by heat over a lamp. The rubber was rather soft, but was of fair quality, the amount of resin present in the dry material being 11·2 and 10·0 per cent., respectively. Both samples were very wet when received, and sample B, which had been prepared by heating, contained a considerable quantity of uncoagulated latex. This defect could, however, be easily remedied, in which case the market value of the rubber would probably be increased. The samples were valued by brokers at 2*s*. 6*d*. and 2*s*. 2*d*. per lb., respectively.

It appears from these experiments that the trees of *Funtumia elastica*, under cultivation in Trinidad, will yield a marketable rubber at the age of four and a half years, whereas the product obtained from *Castilloa elastica* trees of the same age would possess little commercial value.

A sample prepared according to Dr. Weber's method, which was forwarded to the Imperial Institute at the same time, has already been referred to (p. 220).

FERTILIZING AND FEEDING VALUE OF SEA ISLAND COTTON SEED.

In an article on the 'Agricultural Chemistry of Cotton' in the *West Indian Bulletin*, Vol. IV, pp. 241-54, information was given with regard to the composition of cotton seed and its products. The information there given, which was abstracted from *The Cotton Plant*,* related to ordinary or Upland cotton. As most of the cotton being grown in the West Indies is Sea Island cotton, it is proposed in the following pages to give a short summary of information relating to the chemical composition of Sea Island cotton seed as compared with ordinary cotton seed.

The information, it should be stated, is abstracted, with certain modifications as to arrangement of tables and other minor details, from a bulletin† entitled 'A Chemical Study of Sea Island Cotton Seed', by F. S. Shiver. This bulletin forms a record of a large number of analyses of Sea Island cotton seed and its products (kernels, hulls, seed, linters, oil, and

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* Bulletin No. 33, Office of Experiment Stations, U. S. Department of Agriculture.

† Bulletin No. 68, South Carolina Agricultural Experiment Station, 1902.

meal). It is not proposed here to enter into the subject of the composition of the parts of the seed, nor of other products than the cotton seed meal.

Both the seed (whole and crushed) and the meal are used as fertilizers and for feeding purposes. It might be mentioned here that the term 'cotton seed meal' is generally taken to signify the residual product after the expression of the oil from the seed. The use of this term for crushed cotton seed is therefore entirely contrary to the ordinary custom.

It has been suggested that the presence of the oil in cotton seed (whole or crushed) not only causes the seed to be inferior to cotton seed meal (i.e., the residue after the extraction of the oil), but also actually acts deleteriously towards plant growth.

In regard to the first point, experiments appear to have proved conclusively that both cotton seed (whole or crushed) and cotton seed meal are satisfactory manures for supplying nitrogen to cotton; that as between the two there is a *slight* difference in favour of the latter; and that whole cotton seed is as efficacious as ground cotton seed. Any slight superiority possessed by the meal is probably due to its containing plant food in a rather more available form; the effect of this is not as a rule noticeable in the case of, say, cotton and corn, but is apparent when cotton seed is applied to a crop, like Irish potatos, that occupy the land for a shorter time.

With regard to the deleterious action of cotton seed, or rather, of the oil contained in the seed, this is noticed only when large piles of seed are allowed to stand for some time on the ground; the spots covered in this way remain bare afterwards, as if they had been poisoned. No such effects result from the ordinary use of the seed in quantities of, say, 12 to 20 bushels to the acre. When whole cotton seed was used for manurial purposes in the United States, it was found necessary to put the seeds out in the winter, otherwise they were likely to sprout. For similar reasons, it will probably be found more expedient in the West Indies to use crushed seed.

It will be seen that Sea Island seed is of considerably greater fertilizing value than Upland seed, since it contains a higher percentage of all the fertilizing constituents, viz., nitrogen, phosphoric acid, and potash. The total amount of fertilizing constituents in a ton of Sea Island cotton seed is 153·3 ℔., as against 125 ℔. in a ton of Upland seed.

Sea Island cotton seed meal, on the other hand, is not as rich in fertilizing constituents as the meal made from Upland seed, hence it takes 1½ tons of the former to supply the same total amount of these constituents as is contained in 1 ton of the latter.

Turning now to the feeding value of Sea Island seed, the tables show very clearly its superiority in this respect to Upland seed. It is considerably richer in protein and nitrogen-free extract, and slightly richer in fat; it possesses the additional advantage of a lower fibre content. It is apparent, therefore, that Sea Island cotton seed is a rich and valuable food; it must, however, be clearly understood that its nutritive or albuminoid ratio is very narrow, and that it would not be

economical, on this account, to feed it alone to stock. The addition of some carbonaceous material is necessary; for this purpose molasses might well be used. A note in the *Agricultural News*, Vol. III, p. 386, contains interesting information on the successful use of molasses and cotton seed meal for stock; molasses might equally well be used with crushed cotton seed. The most economical use of cotton seed is undoubtedly to feed it to stock and apply the resulting manure to the land.

With regard to the value of Sea Island cotton seed meal as a feeding stuff, Mr. Shiver shows that it is inferior to that of ordinary Upland meal. It should be clearly understood, however, that this inferiority is due solely to differences in the method of manufacture. As, however, no cotton seed oil mills have so far been established in the West Indies, planters will be more particularly interested in the feeding and fertilizing value of the seed than of the meal. It is hoped that the information contained in this article will convince them that they have a local product of high feeding and fertilizing value, which should take the place to a considerable extent of the imported linseed and other meals.

Fertilizing Value of Sea Island Cotton Seed.

The following table shows the average composition of Sea Island cotton seed and of the Upland seed :—

TABLE I.—AVERAGE COMPOSITION OF SEA ISLAND AND UPLAND COTTON SEED.

Constituents.	Sea Island.	Upland.
Moisture	8·030	7·04
Crude ash	4·600	3·29
Nitrogen	3·510	3·07
Phosphoric acid	1·689	1·02
Potash	1·595	1·17
Lime	0·321	0·19
Magnesia	0·665	0·50
Insoluble matter	0 044	0·02

The above data show that the fertilizing value of the Sea Island seed is considerable, exceeding, as we shall see, that of the Upland seed. When we reflect that, on an average, 12·03 per cent. of the weight of the whole Sea Island plant

consists of seed, and that, with an average production of 200 lb. of lint to the acre, 443 lb. of seed are produced, we shall be agreed that the maintenance of the soil fertility will depend largely upon the judicious disposition of this most valuable by-product.

We observe some differences in the composition of the Sea Island and Upland seed. We find that the ash percentages, as well as the percentages of the ash constituents themselves, are lower in the Upland seed than in the Sea Island. The same remark holds good for the nitrogen content also. We should naturally expect to find these differences, since the lint which adheres to the Upland seed in considerable quantities, even with the most efficient ginning, is particularly poor in nitrogen and ash constituents. We see, therefore, from what has gone before, that the Sea Island seed possesses a considerably greater fertilizing value than the Upland seed. According to the data just given, a ton (2,240 lb.) of Sea Island seed and Upland seed would contain the following amounts of the essential fertilizing constituents:—

TABLE II.—FERTILIZING CONSTITUENTS OF ONE TON OF SEA ISLAND AND UPLAND SEED.

Constituents.	Sea Island.	Upland.
Nitrogen	79·7	69·9
Phosphoric acid	37·8	29·1
Potash	35·8	26 0
Total	153·3	125·0

From these results, we see that the fertilizing value of a ton of Upland seed amounts to but 81·5 per cent. of that of a ton of Sea Island seed. In other words, 1,826 lb. of Sea Island seed is equal in fertilizing value to 1 ton of Upland seed. This shows very strikingly the superior fertilizing value of the Sea Island seed as compared with the Upland.

FERTILIZING VALUE OF SEA ISLAND COTTON SEED MEAL.

The most valuable by-product obtained in the manufacture of oil from the cotton seed is the meal. This is especially true in the case of the Sea Island seed, where the hulls obtained are practically a negligible quantity. We find from data obtained from various mills that in actual practice the amount of meal obtained from a ton of Sea Island seed varies from 1,590 lb. to 1,698 lb., or from 71 to 76·25 per cent. While much work has been done on the Upland or ordinary cotton seed meal, comparatively little is known concerning the Sea Island meal and its compostion. A definite knowledge of the

composition of the Sea Island meal is highly important since, when it is used for fertilizing purposes, either by itself or for compounding with other materials, its contents in fertilizing constituents should be accurately known. In other words, it should be bought and sold exclusively on guarantee, as is now done with the Upland or ordinary meal. Looseness in regard to this matter has led some to speak of the Sea Island meal as 'adulterated' cotton seed meal. This can be justified only in those cases where the Sea Island product is sold under the name of the Upland or ordinary cotton seed meal. The value of a product like Sea Island cotton seed meal depends largely upon the methods used in manufacturing the same.

It must be borne in mind that the Sea Island seed is treated very differently from the Upland seed in the process of manufacturing oil and meal. In the case of the Upland seed, it is possible to separate, more or less completely, the hulls from the kernels or 'meats' by means of a system of perforated screens. With the Upland seed, the lint-covered hulls fall together and remain behind upon the screens, the kernels or 'meats' being separated by falling through the perforations of the same. As there is practically no lint on the Sea Island seed, it is not possible, as a rule, to treat them in the manner above described, and consequently the hulls and kernels or 'meats' are pressed together as a general rule for the extraction of the oil, and both are therefore found in the resulting meal.

From these difficulties, involved in separating the kernels or 'meats' from the hulls in the case of the Sea Island seed, one would naturally expect to find the Sea Island meal of varying composition. This we find to be the case in practice.

TABLE III.—AVERAGE COMPOSITION OF SEA ISLAND AND UPLAND COTTON SEED MEALS.

Constituents.	Sea Island.	Upland.
Moisture	9·24	6·89
Crude ash...	5·14	6·35
Nitrogen	4·55	6·87
Phosphoric acid	1·89	2·70
Potash	1·68	1·89
Lime	0·35	0·32
Magnesia	0·84	1·10
Insoluble matter	0·06	0·13

From all of these analyses we observe that the Sea Island cotton seed meal contains quite a considerable amount of the essential fertilizing constituents. When being used for general fertilizing purposes, it will be necessary, however, to supplement it with phosphatic and potassic fertilizers, such as acid phosphate and kainit. For general fertilizing purposes the following formula may be recommended :—

Sea Island meal	(4·6 per cent. N.) ...	870 lb.
Acid phosphate	(15 „ „ av. P_2O_5)	800 „
Kainit	(12·5 „ „ K_2O) ...	330 „
	Total ...	2,000 lb.

When we come now to compare the average composition of the Sea Island and Upland meals, we observe at once that the former is considerably poorer in two of the essential fertilizing constituents—nitrogen and phosphoric acid. As regards the potash, we notice that there is very little difference in the amounts contained by the two kinds of meal under consideration. The percentages of lime and magnesia are quite uniform throughout, with a tendency, however, to higher results in the Upland meal. The amount of insoluble matter is higher in the Upland meal but still considerably lower in every case than the maximum allowed by Schulze for the sand content, namely, 0·5 per cent. (*Landw. Versuchs Stationen*, 1896). Calculating out, we find that a ton of Upland meal, based on the average results given above, contains 256·7 lb. of the essential fertilizing constituents, while a ton of Sea Island meal contains 181·9 lb. However, for general fertilizing purposes, it may be better sometimes to use the Sea Island meal, since it is a better-balanced fertilizing material than the Upland. But, if it is one's desire to buy a high-grade ammoniate, it will be better, of course, to make use of the Upland meal.

TABLE IV.—PERCENTAGES OF NITROGEN, AVAILABLE PHOSPHORIC ACID, AND WATER-SOLUBLE POTASH IN SEA ISLAND AND UPLAND COTTON SEED MEALS.

Constituents.	Sea Island.	Upland.
Moisture	9·24	6·89
Nitrogen	4·55	6·87
Available phosphoric acid ...	1·76	2·52
Water-soluble potash	1·37	1·60

Comparing the average results obtained on the Sea Island and Upland meals, we notice that the percentages of all the essential fertilizing constituents, with the possible exception of the water-soluble potash, are considerably lower in the case of

the Sea Island meal. The differences, however, in the percentage availability of the phosphoric acid and the percentage solubility of the potash are comparatively slight, though there is a tendency to higher figures in the case of the Upland meal. As concerns the relative commercial value of the two kinds of meal in question, we notice that a ton of Sea Island meal is worth not quite three-fourths as much as a ton of Upland. In other words, for fertilizing purposes a ton of Upland meal is worth nearly as much as 1½ tons of Sea Island, as will be seen from the following calculations:—

Constituents.	Sea Island Meal, 1½ tons.	Upland Meal, 1 ton.
Nitrogen	152·8	153·8
Available phosphoric acid...	59·1	56·4
Water-soluble potash ...	46·0	35·8
Total	257·9	246·0

Feeding Value of Sea Island Cotton Seed.

The following table shows the average results of proximate analyses of Sea Island cotton seed in comparison with Upland and Egyptian seed:—

Table V.—Average proximate analyses of Sea Island, Upland, and Egyptian cotton seed.

Constituents.	Sea Island.	Upland.	Egyptian.
Moisture	8·03	8·46	11·10
Crude protein ...	21·96	19·28	19·72
Crude fat	20·79	20·36	25·05
Crude fibre	14·85	22·06	19·53
Crude ash	4·59	3·95	4·24
Nitrogen-free extract	29·76	25·86	20·36

The average of the analyses would show the seed to contain, in round numbers in the air-dry condition, 8·0 per cent. of moisture, 22·0 per cent. of protein, 20·8 per cent. of fat (oil), 14·9 per cent. of fibre, 4·6 per cent. of ash, and 29·7 per cent. of

nitrogen-free extract, including 12·2 per cent. of pentosans. We recognize the great feeding value of the Sea Island seed, when we reflect that over 40 per cent. of the same consists of protein and fat. Assuming the same co-efficients of digestibility for the food constitutents contained in the Sea Island seed, as has been found for the Upland seed. we find the nutritive ratio of the former to be 1 : 4·4, and the fuel value 1,528 calories. From these figures it will be seen that the Sea Island seed has a very narrow nutritive ratio, and is therefore not a properly balanced food. In order to make it such it will be necessary to add some carbonaceous food. We observe, also, that the seed has quite a high fuel or calorific value. This was to have been expected from the high fat (oil) content. The commercial value of the Sea Island seed, for feeding purposes, as based on the valuations already given, would be $29·14 per ton. According to these results, a bushel (40 lb.) of Sea Island seed would be worth, for feeding purposes to the farmer, about 50c. This figure may be a little high, and, under the conditions which prevail at present, it is probable that the valuations of the seed and its products would be more correctly expressed by basing them on the fertilizing constituents contained rather than on the food constituents as has just been done.

From the results given in the foregoing table showing the comparative composition of Sea Island, Upland, and Egyptian seed, it would seem that the Sea Island *seed* contains more *protein* than either the Egyptian or Upland. As regards the fat (oil) content, it is to be observed that the Egyptian seed is the richest in this constituent ; it is probable that there is not much difference in the Sea Island and Upland seed in this respect. The Sea Island seed is the lowest in fibre, and the Upland seed the highest. This was to have been expected since the Upland seed retains a considerable part of the lint and we know this is particularly rich in fibre. From what has been said, it is probable that for purposes of oil production, the Egyptian seed is superior to either the Upland or Sea Island seed. As concerns the two latter, it is probable that there would be very little difference in this respect, though the Upland seed may be a little superior. For feeding purposes, the Egyptian and Sea Island seed would appear to have about the same value, both being superior in this respect to the Upland.

As already stated, it has been seen that, with a yield of 200 lb. of lint per acre, there is obtained on an average 443 lb. of seed. We will now consider the amounts of food nutrients obtained per acre from this average amount of seed :—

TABLE VI.—POUNDS OF FOOD NUTRIENTS OBTAINED PER ACRE FROM SEA ISLAND SEED.

	Pounds per acre.						
	Seed.	Crude protein.	Crude fat.	Crude fibre.	Crude ash.	Nitrogen-free extract.	Total.
Sea Island seed	443	97·3	92·1	65·8	20·3	131·8	407·4

From these results we notice that the average amount of food nutrients, produced per acre by the Sea Island seed from an average crop of lint, is quite considerable. The profits obtained in growing the lint will depend very largely upon the disposition which is made of this most valuable by-product. The most rational method of procedure would be to feed the seed and use the resulting manure for fertilizing purposes. It has been shown by experiment that, when the manure is properly saved, 80 to 90 per cent. of the fertilizing constituents, contained in the original food, is recovered in the manure. In this way, we should get a double value for the seed.

FEEDING VALUE OF SEA ISLAND COTTON SEED MEAL.

The average composition of Sea Island cotton seed meal is shown in the following table in comparison with Upland and Egyptian meals :—

TABLE VII.—AVERAGE PROXIMATE ANALYSES OF SEA ISLAND, UPLAND, AND EGYPTIAN COTTON SEED MEALS.

Constituents.	Sea Island.	Upland.	Egyptian.
Moisture	9·24	6·89	11·84
Crude protein... ...	28·43	42·96	26·82
Crude fat	7·86	9·55	7·23
Crude fibre	15·92	6·96	19·00
Crude ash	5·14	6·35	6·24
Nitrogen-free extract	33·41	27·29	28·87

From these results we observe that the Sea Island meal contains, on an average in round numbers, in the air-dry condition, 28 per cent. of protein, 8 per cent. of fat, 16 per cent. of fibre, 5 per cent. of ash, and 33 per cent. of nitrogen-free extract. We are impressed with the great feeding value of the Sea Island meal, when we reflect that nearly 40 per cent., or two-fifths of the same, consists of protein and fat.

Assuming the same digestibility for the food constituents contained in the Sea Island meal, as has been found for the Upland or ordinary meal, we should have the nutritive ratio of 1 : 1·7, and a fuel value of 1,266 calories. The relative commercial value of a ton of Sea Island meal for feeding purposes, based on the valuations already given, would be $21·41. The nutritive ratio of the Sea Island meal is very narrow, and hence it is not a properly balanced food. In order to make it such, it will be necessary to add some carbonaceous food material, such as hulls.

We consider now, finally, a comparison between the composition of the Sea Island, Egyptian, and Upland cotton seed meals, as given in the above table.

From these results we observe that the Upland or ordinary meal is considerably richer in food constituents, especially protein, than either the Sea Island or Egyptian meal. This, of course, is due to the fact that the former contains a smaller amount of hulls than the latter, as the percentages of fibre very clearly indicate. Basing comparisons on the amount of protein contained, we may say that 1 ton of Upland meal is equivalent to about $1\frac{1}{2}$ tons of Sea Island. It will be noticed that the average fat (oil) content is considerably higher in the case of the Upland meal. This fact has already been observed when discussing the relative efficiency of mills, working the Upland and Sea Island seed. On comparing the results for the Egyptian and Sea Island meal in the above table, it will be noticed that, on the whole, there is comparatively little difference in composition. This is not to be wondered at, when we reflect that the methods used in the manufacture of these two kinds of meal are practically identical.

THE BARBADOS BANANA INDUSTRY.

The following account of the shipment of bananas from Barbados appeared in the *Journal of the Society of Arts* of November 11, 1904. As this forms a fairly complete statement of the progress of this new industry, it is reproduced here for general information :—

The fact that very large consignments of bananas from Jamaica and Costa Rica have recently arrived in this country has drawn attention, not only to the increased favour in which this fruit is now held by all classes in the British Isles, but

also to the capabilities of its very much further extension, with the view of supplying a wholesome and nutritious fruit at a cheap rate at times when home-grown fruits are not available. Though large quantities of bananas come to us from our own colony of Jamaica, it must not be forgotten that other countries contribute very extensively to the general imports, and it would seem that a good opportunity has now occurred for pushing forward the cultivation in, and the exportation from, other British colonies.

In connexion with this it does not appear to be generally known that Barbados has already taken the matter in hand and is now cultivating and exporting a fine quality of fruit, the history of which is as follows:—

As is well known, for many years past the staple product of this island has been sugar, but this crop has for a long period been an unprofitable one, and more remunerative crops have been sought. In 1902, shipments of Barbados potatos, which are perhaps better known as sweet potatos, were made under the instructions of Sir Daniel Morris, K.C.M.G., the Imperial Commissioner of Agriculture for the West Indies, but in spite of every effort being made to introduce them to public favour, they were not generally appreciated, and the attempt ended in failure; while, however, shipping the potatos, a few bunches of bananas were sent as an experiment, and were found on arrival to be of splendid quality and flavour, although in bad condition owing to faulty packing and handling. After some experimenting this trouble was overcome, and small consignments were sent which arrived in perfect condition. The consignments were then considerably increased, but the results were still unsatisfactory, for although it was comparatively easy to bring a few crates, the case was quite different when a large number were shipped at one time; the temperature of the holds of the steamers became very high owing to the fact that the fruit when ripening always generates a certain amount of heat. For this reason, several consignments arrived with about 90 per cent. of the fruit rotten. However, on the strong advice of Sir Daniel Morris, the shipments were continued, and eventually, by the installation of a proper system of ventilation on the Royal Mail steamers, complete success has been attained, so that the fruit now received in bad condition does not exceed 1 per cent., and that is usually the result of inexperience in shipping.

From the first, no attempt has been made to compete with the Jamaica banana industry, the fruit grown in Barbados being a different kind from that shipped from Jamaica, which is a large-fruited variety known as the 'Gros Michel.' It grows on plants 14 or 15 feet high, and is capable of being roughly handled without any appreciable damage. The Barbados banana is the same variety as that grown in the Canary Islands and Madeira, and is known as the 'dwarf' or 'Chinese' variety. Its height does not exceed 10 or 12 feet, but the bunches are, as a rule, large and heavy, and the fruit of good size; the flavour is decidedly superior to the fruit either

from the Canary Islands or Madeira, which is probably due to the richer nature of the Barbados soil. The plants are propagated from the shoots from old roots, known as suckers, which are placed in the ground at about 10 feet apart. They should be well manured if large bunches are wanted, and the plants also require a considerable amount of moisture. When the fruits are young, the bunch remains almost upright; but as it matures, the stalk bends over under the weight of fruit, and forms a convenient 'handle' for carrying.

In about eleven months from the time of planting, the bunch is ready to cut, but the exact time to do this can only be known from long experience, and this lack of experience is the usual cause of failure in starting.

The Jamaica banana can be shipped naked, and arrives in England in good condition; but the Barbados fruit, being much more delicate, has to be packed, as it is quite impossible to ship it otherwise. On being cut, it is sometimes packed in the field, and sometimes sent to a central packing-house, but wherever it is packed, it is handled with the greatest possible care, as a slight bruise or rub when the fruits are still green, in which condition the bunch is of course always shipped, would, when ripe, show a black mark, which would considerably reduce its value in the English market. So great is the care given to avoid this, that the Barbados fruit arrives in England in better condition than any other kind, many of the bunches being absolutely free from marks.

The method of packing is simple, but the packer requires considerable experience. The bunch is first wrapped in a sheet of cotton wool, which preserves it from injury and absorbs moisture; it is next wrapped in a sheet of thin paper to keep the cotton wool in place. It is then placed in a crate in which a layer of dead banana leaves, or 'trash' as they are called, has been placed. The bunch is then carefully packed round with more 'trash', and the top of the crate nailed on. The crate is then marked with a certain number of crosses to denote the size of the bunch it contains, and with the distinguishing mark of the shipper.

In the Canary Islands, the fruit is generally shipped by merchants, but in Barbados a much better system is in vogue. The consignments are made by Mr. J. R. Bovell, Agricultural Superintendent in Barbados, and each grower or shipper has his own mark and number, a necessary arrangement to avoid confusion. All the fruit shipped by Mr. Bovell is consigned to one firm, having very extensive stores at Plymouth and Portsmouth, and as this firm makes a point of supplying it direct to shopkeepers, and not to wholesale merchants or middle-men, the amount of money wasted in useless profits is nil. The grower is practically in direct communication with the shopkeeper, and has only to pay the small fee for shipping from Barbados, and the expenses of distributing here. In this way, he obtains a better price for his fruit, and the shopkeeper can buy it at a lower price, than would be the case if it passed through several hands, as it does in the Canary Islands. In order that the fruit may be known by a definite name, the

trade mark 'Dagger Brand' has been registered, and this is placed on all the crates which contain nothing but absolutely the finest fruit. Being a new industry, it has been possible to organize it on the best possible lines.

The greater part of the fruit is shipped to Plymouth, and when the Royal Mail steamer passes the Lizard her arrival is telegraphed to Plymouth: the mail tender then goes out to meet her to bring ashore the mails and passengers: at the same time several large lighters are towed out by a steam tug to bring ashore the fruit, the crates are slung out of the holds and lowered into the lighters. When the lighters are full, they are covered with tarpaulins to protect the fruit, and are either towed in again or sail in, according to the state of wind and tide: they proceed into Sutton Harbour to the wharf, on which the stores are situated and to which they are transferred, where every crate is examined, and stacked according to the degree of ripeness of the contents. In order to facilitate ripening, the stores are divided into several compartments, which can be heated to various temperatures. These stores are probably the largest of this kind in the country, having a floor-area of nearly a quarter of an acre. So great is the demand for the fruit that it is very rapidly sold, and at the present time the immediate neighbourhood of Plymouth takes practically all that is shipped. The imports, however, are increasing, nearly 1,000 crates of these Barbados bananas having recently been landed at Plymouth from one of the Royal Mail steamers, all of which arrived in splendid condition, a result due to a great extent to good packing, but also to the fact that Barbados is the nearest to England of the West India Islands, and the last place touched by the steamers.

The industry is the result of the labours of Sir Daniel Morris, Mr. J. R. Bovell, and the other officials of the Imperial Department of Agriculture, but it could never have been properly organized without the active help of the officers of the Royal Mail Steam Packet Company, who carried all the experimental shipments free and made considerable alterations in the ships to fit them for the traffic. The ships' officers have taken a great interest in the industry, and the splendid condition of the fruit on its arrival is largely due to the skill with which they handle it. As an instance of the trouble they take it may be mentioned that the temperature of the ships' hold is examined every six hours during the voyage, and regulated as is necessary.

ON ASCERTAINING THE STRENGTH OF LIME JUICE AND OF SOLUTIONS OF CITRIC ACID BY MEANS OF A HYDROMETER.

BY THE HON. FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.

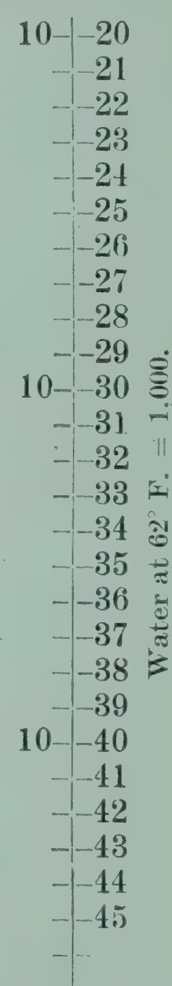
A demand arises from time to time for a simple method of ascertaining the strength of lime juice and of solutions of citric acid. This is readily effected by chemical methods, but there is room for a more simple method whereby these strengths can be estimated approximately.

This can be done by means of a suitable hydrometer.

In order to facilitate work in this direction I have prepared the following table showing the specific gravity of the solution at a temperature of 30°C. (86°F.) when determined by means of a glass hydrometer standardized at a temperature of 62°F. (16·6°C.). In appropriate columns are given (1) the number of grammes of citric acid in 100 c.c. of solution (by moving the decimal point one place to the left these figures are converted into pounds of citric acid per gallon); (2) the number of ounces of citric acid in a gallon of solution. These two apply to pure solutions of citric acid; but as lime juice contains other substances than citric acid which influence the specific gravity, a number of samples have been examined, and it has been found that the citric acid may be more correctly determined by taking 82 per cent. of the quantity which would be indicated in a pure solution.

In the remaining columns there are therefore set out (3) the (approximate) number of grammes of citric acid in 100 c.c. of lime juice, which, by moving the decimal point one place to the left is converted into the corresponding number of pounds of citric acid per gallon; and (4) the (approximate) number of ounces of citric acid in a gallon of lime juice.

In order to use these tables all that is required is a glass hydrometer suitably graduated. For this purpose I suggest that the hydrometer may conveniently have a scale as follows:—



The instrument itself is *graduated* at a temperature of 62°F., but it is to be *used* at ordinary tropical temperature, or to be accurate at 30°C. or 86°F. It is simply floated in the sample of juice, the indication on the scale which exactly corresponds with the surface of the juice is read off and the corresponding information read off from the table.

Thus, if the instrument floats with the indication 1,036 exactly level with the surface of the liquid, we learn from the table that the liquid contains, if lime juice, approximately,

8·47	grammes of citric acid			per 100 c.c.
·847	pounds	,,	,,	,,	per gallon.
13·56	ounces	,,	,,	,,	per gallon.

If the solution were one of pure citric acid it would indicate

10·33	grammes of citric acid			per 100 c.c.
1·033	pounds	,,	,,	,,	per gallon.
16·54	ounces	,,	,,	,,	per gallon.

The hydrometer and the table may be used to ascertain approximately the strength of concentrated lime juice, by carefully diluting the concentrated juice with water to ten times its volume. This may conveniently be done by accurately filling with concentrated juice a flask holding exactly 100 c.c., then transferring this juice to a flask holding 1,000 c.c. (one litre) and filling up the 1,000 c.c. flask with water. The small flask must be carefully washed out with the water used for diluting so that all the concentrated juice measured in the 100 c.c. flask is transferred to the large flask.

The hydrometer is floated in the diluted juice, the reading noted and multiplied by ten to give the strength of the concentrated juice.

Thus:—If the hydrometer floats at 1,029 in the diluted juice, the strength is (approximately) 11·04 oz. per gallon, or, in the concentrated juice, 110·4 oz. per gallon.

It must be remembered that with anything but pure solutions the results are only approximately correct, but it is believed that they will be sufficiently accurate to be useful in ordinary estate practice.

TABLE FOR ASCERTAINING THE STRENGTH OF SOLUTIONS OF CITRIC ACID AND OF LIME JUICE. FOR USE WITH GLASS HYDROMETERS AT TROPICAL TEMPERATURE.

Sp. Gr. $\frac{30^\circ}{16\cdot5^\circ}$	In pure solutions of citric acid.		In lime juice.	
Reading of Instrument.	Grammes of citric acid per 100 c.c. of solution.	Ounces of citric acid per gallon of solution.	Grammes of citric acid per 100 c.c. of juice.	Ounces of citric acid per gallon of juice.
1,000	0·57	0·87	0·47	0·71
1	0·83	1·30	0·68	1·07
2	1·08	1·73	0·89	1·42
3	1·35	2·16	1·11	1·77
4	1·62	2·59	1·33	2·12
1,005	1·89	3·02	1·55	2·48
6	2·17	3·46	1·78	2·84
7	2·45	3·99	2·01	3·27
8	2·71	4·32	2·22	3·54
9	2·96	4·75	2·43	3·90
1,010	3·23	5·18	2·65	4·25
11	3·50	5·61	2·87	4·60
12	3·78	6·04	3·10	4·95
13	4·04	6·47	3·31	5·31
14	4·30	6·90	3·53	5·66
1,015	4·58	7·33	3·76	6·01
16	4·86	7·76	3·99	6·36
17	5·12	8·19	4·20	6·72
18	5·40	8·63	4·43	7·08
19	5·67	9·07	4·65	7·44
1,020	5·94	9·50	4·87	7·79
21	6·22	9 94	5·10	8·15
22	6·50	10·48	5·33	8·59
23	6·78	10·82	5·56	8·87
24	7·05	11·26	5·78	9·23
1,025	7·32	11·70	6·00	9·59

TABLE FOR ASCERTAINING THE STRENGTH OF SOLUTIONS OF CITRIC ACID AND OF LIME JUICE. FOR USE WITH GLASS HYDROMETERS AT TROPICAL TEMPERATURE.—*Concluded.*

Sp. Gr. $\frac{30^{\circ}}{16{\cdot}5^{\circ}}$	In pure solutions of citric acid.		In lime juice.	
Reading of Instrument.	Grammes of citric acid per 100 c.c. of solution.	Ounces of citric acid per gallon of solution.	Grammes of citric acid per 100 c.c. of juice.	Ounces of citric acid per gallon of juice.
1,026	7·59	12·14	6·22	9·95
27	7·87	12·58	6·45	10·32
28	8·14	13·02	6·67	10·68
29	8·42	13·46	6·90	11·04
1,030	8·69	13·90	7·13	11·40
31	8·97	14·34	7·36	11·76
32	9·24	14·78	7·58	12·12
33	9·52	15·22	7·81	12·48
34	9·79	15·66	8·03	12·84
1,035	10·06	16·10	8·25	13·20
36	10·33	16·54	8·47	13·56
37	10·60	16·97	8·69	13·92
38	10·88	17·41	8·92	14·28
39	11·15	17·85	9·14	14·64
1,040	11·42	18·28	9·36	14·99
41	11·70	18·72	9·59	15·35
42	11·98	19·16	9·82	15·71
43	12·25	19·59	10·05	16·06
44	12·51	20·02	10·26	16·42
1,045	12·78	20·45	10·48	16·77
46	13·04	20·88	10·69	17·12
47	13·30	21·30	10·90	17·47
48	13·57	21·73	11·12	17·82
49	13·84	22·16	11·35	18·17
1,050	14·11	22·59	11·57	18·52

DIFFERENCE TABLE FOR THE CALCULATION OF FRACTIONAL PARTS.

Sp. Gr. $\frac{30°}{16·5°}$	In pure solutions of citric acid.		In lime juice.	
Reading of Instrument.	Grammes of citric acid per 100 c.c. of solution.	Ounces of citric acid per gallon of solution.	Grammes of citric acid per 100 c.c. of juice.	Ounces of citric acid per gallon of juice.
·1	·03	·04	·02	·03
·2	·05	·08	·04	·07
·3	·08	·13	·07	·11
·4	·11	·17	·09	·14
·5	·13	·21	·11	·17
·6	·16	·26	·13	·21
·7	·19	·30	·16	·25
·8	·22	·34	·18	·28
·9	·24	·38	·20	·31

BACTERIA AND THE NITROGEN PROBLEM.

The following paper by Mr. George T. Moore, Physiologist in Charge of the Laboratory of Plant Physiology, Bureau of Plant Industry, appeared in the *Yearbook* of the U.S. Department of Agriculture for 1902 and was briefly reviewed in the *Agricultural News*, Vol. III, p. 51 :—

There is probably no fact in plant physiology which has been more firmly established than that all plants must have nitrogen in order to thrive, and that under normal conditions this nitrogen must be obtained through the roots in some highly organized form. It is not necessary to discuss this point, for practical experience demonstrates its truth every time a soil is exhausted by any crop, and the farmer testifies to his belief in this fact when he tries to re-establish the fertility of his ground by adding some fertilizer rich in nitrogenous matter. While there are certain other substances, such as phosphoric acid, potash, iron, etc., which plants must have and can only obtain through the soil, the demand for nitrogen is so

much greater, and in one sense so much more important, that the question of the available nitrogen supply in the world has come to be looked upon as lying at the very foundation of agriculture and demanding the most careful consideration. Since the conditions of life in the civilized quarters of the globe are such as to cause a constant loss of nitrogen, there have been some who have predicted what has been termed a 'nitrogen famine,' which is to occur within the next forty or fifty years, and the possibility of such a catastrophe has been very graphically portrayed. On the other hand, there are investigators who feel that the possibility of such a condition has been much exaggerated and that the amount of nitrogen in the soil can never be exhausted to such an extent as to affect the crop-producing power of the earth. In order that we may be able to form a more definite opinion upon the subject, it may be well to look at some of the ways in which nitrogen is lost, and then see how it may be reclaimed.

HOW NITROGEN IS LOST.

In the first place, the conditions of life on the ordinary farm are such as to cause the constant loss of this valuable element through the removal of the crops taken from the soil. If every crop that grew on the land could be returned to it, nature has made provision for getting it back in suitable form for plant food. In the case of nitrogen, neither plants nor animals are able to produce this substance directly in an available form. It is necessary that certain bacteria take hold of plant and animal products, and by means of peculiar changes produce nitrates from their fats, sugars, starches, etc. Without these bacteria everything would have come to a standstill long ago, for unless decay takes place, and the decomposed elements are re-arranged into definite nitrogenous salts, no plant is able to use them. Thus, it will be seen that certain bacteria in the soil play as important a part in the food supply of the earth as do the animals and larger plants upon which we think we are so dependent.

It is hardly necessary to refer to the vast waste of nitrogenous material that is involved in modern sewage methods. Millions of dollars' worth of nitrogen which would naturally return to the soil under the action of nitrifying bacteria is every year carried off in various waterways and ultimately reaches the ocean, where, of course, it is of no benefit to man. More than fifty years ago Liebig said on this subject:—

'Nothing will more certainly consummate the ruin of England than the scarcity of fertilizers. It means the scarcity of food. It is impossible that such a sinful violation of the divine laws of nature should forever remain unpunished, and the time will probably come for England, sooner than for any other country, when with all her wealth in gold, iron, and coal she will be unable to buy the one-thousandth part of the food which she has during hundreds of years thrown recklessly away.'

A third great source of nitrogen loss is through the action of a group of bacteria which have the power of breaking down

nitrates, depriving them of oxygen, and reducing them to ammonia or nitrogen gas, when they are, of course, unavailable for plant food. This process of denitrification, while very useful in the septic tank, which is the most sanitary method of sewage disposal, is the source of considerable loss to the farmer, and manures may often be rendered practically worthless by the action of these bacteria.

Other means by which nitrogen is lost, so far as plant foods are concerned, are the washing out of nitrogen salts from the soil and the burning of explosives which are largely composed of some nitric salt that would be directly valuable to the vegetable kingdom. The action of nitrate of soda or saltpetre has been studied experimentally, and it is known that up to a certain maximum about 23 lb. of nitrate of soda will yield an increase of 1 bushel of wheat per acre. Thus, when hundreds of thousands of tons of explosives are used in waging war, every battle liberating nitrogen which if applied to the soil would increase the yield of wheat by thousands of bushels, the actual cost of war should be estimated at considerably more than is usually calculated ; and if there is soon to be a nitrogen famine, war becomes more serious than ever before.

With all of these destructive forces at work, and nitrogen being liberated on every hand, it is no wonder that thinking men have become alarmed at the prospect, and have endeavoured in every way possible to discover some means of increasing the world's supply of this most necessary element.

HOW NITROGEN IS GAINED.

The most valuable compound containing sufficient fixed nitrogen to be used in any quantity as a nitrogenous fertilizer is the nitrate of soda, already referred to as the basis of so many explosives. This salt occurs naturally in certain regions of Chili and Peru, where for countless centuries the continuous fixation of atmospheric nitrogen has been carried on by bacteria. Unfortunately, however, like any other mineral supply in the earth, the quantity is limited, and although it is difficult to get accurate estimates of the amount of nitrate remaining in the beds, authorities seem to agree that, at the present rate of export, the raw material will all be exhausted within from forty to fifty years. To show how much more rapidly this supply is being exhausted than was thought possible forty years ago, it is only necessary to state that in 1860 all estimates showed that the amount of nitrate of soda then known would last for nearly fifteen hundred years. The demand has rapidly increased, however, and although the output is controlled, there is annually consumed in the world's markets nearly 1½ million tons of nitrate of soda, representing a value of about $100,000,000. Of this amount, the United States requires about 15 per cent., and it is by far the most expensive fertilizer that is in use by the farmer.

In addition to the nitrate of soda beds there have also been large deposits of guano, which have served as one of the principal sources of nitrogen. The greater part of the guano beds are now completely exhausted however, and although

new deposits are occasionally discovered, they are of such limited area, or of such a low percentage of nitrogen, as to have practically no effect upon the available nitrate supply.

There are certain other chemical salts which furnish a limited amount of nitrogen, such as the product which remains from the distillation of coal in the process of gas making, but all of them are obtained in such comparatively small quantities that they are not worth taking into consideration when one realizes the enormous amount of nitrogenous fertilizer necessary to replace the combined nitrogen which is annually removed from the soil in one way or another.

Ever since the importance of increasing the combined nitrogen supply has been realized, men of science have naturally turned to the atmosphere as being the most promising field for experiment and the one most likely eventually to solve the whole problem. When it is remembered that nearly eight-tenths of the air about us is nitrogen, and that plants are able to obtain their entire source of carbon from a gas which is present in the comparatively small proportion of one-tenth of 1 per cent., it seems almost incredible that there should be any more difficulty about a plant's nitrogenous food than about its supply of carbon dioxide. Since it seemed so well settled, however, that plants could not use nitrogen as a gas, the chemists and physicists have made every effort to devise some mechanical means of making this element available in a combined form. It has been known that discharges of lightning passing through the air are able to fix free nitrogen, and, beginning with this as a basis, some very satisfactory results have been obtained by the use of electricity. With a power sufficiently cheap and with perfect machinery, there seems good reason to believe that in the near future it will be possible to place upon the market a manufactured nitrate of soda or nitrate of potash that will be superior in quality to the deposits found in South America, and that will also be reasonable enough in price to compete with the natural product.

NITROGEN-FIXING BACTERIA.

Fortunately, there are still other means by which nitrogen gas may be made available for plant food, and that, too, without requiring the introduction of a commercial product, which must always be rather expensive, whatever degree of perfection may be reached in the mechanical operation of the process. Ever since the earliest days of agricultural science, it has been noticed that certain land, if allowed to stand fallow for a considerable length of time, would gain in nitrates without any visible addition having been made. It is now known that one of the principal means of this increase in nitrogen content is due to a few forms of soil bacteria which have the power of fixing the free nitrogen from the air and rendering it available for plant food. These organisms have been isolated and cultivated artificially, and great hopes were held at one time that it would be possible to inoculate land with these cultures and thus bring about a large increase in the nitrogenous salts without the aid of any manure or mineral

fertilizer. Under certain conditions these bacteria seemed able to do a large amount of work, and there are experiments on record where the crops raised from plots inoculated with nitrogen-fixing organisms were much greater than crops from uninoculated land. Unfortunately, these results were not always constant, and such a large percentage of failures had to be reported that from a practical standpoint the use of such cultures is now considered worthless. A matter of such vast importance to agriculture, however, should not be neglected simply because of first failures. It is quite possible that, as we become better acquainted with the habits of these bacteria and learn the conditions which are most favourable to fixing nitrogen and the causes which prevent this operation from going on at all times, we shall be able to discover some means of using these nitrogen gatherers in practical farming.

ROOT-TUBERCLE BACTERIA.

In the meantime there is still one other means at hand which can be used, and has been used for countless centuries, as a most efficient method of conserving the world's nitrogen supply. Ever since the time of Pliny and other early writers upon agricultural topics, it has been known that certain leguminous crops, such as clover, beans, peas, etc., did not require the same amount of fertilizer as other plants, and indeed it seemed as though they actually benefited the soil instead of being a detriment. Various theories have been advanced to account for this effect, perhaps the most wide-spread opinion being that members of this family, owing to the unusual length and strength of their root system, were able to draw upon a store of food that was not available to wheat and corn and other crops not belonging to the pod-bearing group. It is only within a comparatively recent time that the real cause of the beneficial effect of these legumes has been fully understood, and it seems that here again the bacteria are responsible for the nitrogen-gathering power; for it is because these plants are able to fix and use the free nitrogen of the air that they are of such benefit in rotation and in reviving poor and exhausted land. The immense yields of wheat following alfalfa or clover are easily understood when it is realized that there has actually been added to the soil a certain definite amount of nitrogen in such form that the wheat can be benefited by it. Such efficient users of the atmospheric nitrogen are clover and peas and similar crops that they can actually live and thrive in a soil that has not the first trace of combined nitrogen within it. If quartz sand be ignited to red heat, thus burning out all the nitrates, and then be planted with peas or beans, it is possible to bring these plants to full maturity without in any way allowing a particle of fixed nitrogen to find its way into the soil. On the other hand, wheat or potatos, or crops not legumes, will die as soon as the small amount of nitrogen available from the seed is exhausted. What is the reason for this? It can not be merely a difference in the length or extent of the root system, because plants flourish where it is certain there are no available nitrates whatever. For a long time the presence of certain peculiar

nodules or tubercles upon the legumes has been noted and speculated upon. These formations are always present upon the roots of leguminous plants grown under proper conditions, and may vary in size from that of the smallest pin head, in some clovers, to a cluster as large as a potato, as in the case of the inoculated roots of a velvet bean plant. They have been thought to be due to the bites of worms and insects, or to be caused by conditions of the soil and various abnormal climatic effects, and only within very recent years has it been learned that these formations are due to the presence of innumerable bacteria, and that unless these tubercle-producing bacteria exist, the plant is no more able to use the nitrogen from the air than wheat or any of the other crops which do not have such nodules on their roots.

MICROSCOPIC APPEARANCE OF TUBERCLES.

If a thin cross section of one of these tubercles be examined under the microscope, it will be seen that the cells are very much larger than in a normal root, and that almost the entire contents have been replaced by masses of minute bacteria. These bacteria gain an entrance into the plant through the root hairs, and may assume shapes very different from the ordinary rods and spheres that are usually found in this group. The appearance of branching forms has led some observers to consider that these tubercle formers were not true bacteria, but belonged to some group intermediate between the bacteria and fungi. This is not probable, however, for there is abundant evidence to prove their relationship to the true bacteria, and while the peculiar shapes are somewhat characteristic of the group, they are not exclusively of this form, many tuburcles having nothing but the short rods.

Just where the nitrogen is fixed and how it is used by the plant have been debated questions. Some have supposed that the presence of the bacteria in the roots simply acted as a stimulus, and that the leaves of the plant were thus able to take in nitrogen as a gas and to elaborate nitrates from it in some such way as carbon is formed from carbon dioxide. It seems much more probable, however, that the bacteria themselves fix the nitrogen in the roots of the plant, and that it is then used as nitrates would be used from the soil. It is certain that these tubercle organisms can fix free nitrogen in cultures, and there is no reason to suppose that this power is lost when within the roots of a legume. Furthermore, it seems as though the plant actually uses the contents of these tubercles, for at the end of the season the tubercles are found to be much softer and shrunken, and are practically emptied of their mass of bacteria.

It is a well-established fact, and has been shown by a number of independent investigators in various parts of the country, that the leguminous crop which bears tubercles will exceed a similar crop without tubercles by from 100 to 1,000 per cent.; that is, a field of clover grown on such poor soil that it would only yield 200 lb. to the acre would be so invigorated by the presence of tubercle-forming bacteria that on exactly similar

soil it would produce from 400 lb. to 2,000 lb. to the acre, and this without any cost whatever for fertilizers and with very little more labour. In addition to the increase of the actual weight of the crop, tubercles also cause the plants to flower and fruit earlier, and the number of seeds produced is very much greater.

Thus it will be seen that it is worse than useless to attempt to grow any leguminous crop without being certain of the presence of the bacteria which enable the plant to fix free nitrogen. It would be much better to fertilize heavily and attempt to raise some more profitable crop than to introduce clover or beans or some other legume for the purpose of enriching the soil. It cannot be too strongly emphasized that unless the tubercles are present the leguminous crop is of absolutely no more benefit to a soil than wheat or potatos.

While these organisms are pretty generally distributed throughout the earth, and it is quite possible in many parts of the country to grow almost any leguminous crop and secure these tubercles, it is also true that certain regions are practically devoid of the right kind of bacteria, and that unless some artificial means of introducing the germs be resorted to, the crop will be a failure.

ARTIFICIAL INOCULATION OF THE SOIL.

In the past there have been two methods used in attempting to bring about artificial inoculation. Naturally, where a certain leguminous crop has been grown successfully for a number of years, the soil will become filled with tubercle organisms, and by transporting this earth to new fields the organisms will thus become available for forming the nodules in localities where they previously had not existed. This was the means by which the soy bean organisms were brought from Japan, and there are very few places in this country where soy is now grown that did not receive their inoculation, indirectly at least, from the Japanese soil.

There are two serious objections to soil inoculations, however. One is the expense; for it requires anywhere from 500 lb. to 1,500 lb. of earth per acre to produce a satisfactory growth of tubercles, and if this has to be transported for a large farm, the cost is almost prohibitive. There is still another and more serious objection, however, and that is the danger of transmitting plant diseases by this method. Several of the more serious diseases which attack crops are readily conveyed in the soil, and there are numerous cases on record where diseases of leguminous and other crops have been introduced into regions previously entirely free from them through an effort to bring about soil inoculation of the tubercle-forming organism. Consequently, if any safer and cheaper method could be devised for making these germs available, it would be most desirable.

A few years ago certain German investigators put upon the market a product known as nitragin, which purported to be a pure culture of the root-tubercle organism. These cultures were only adapted to specific crops, for it has been held that each kind of leguminous plant has a special germ better adapted to produce tubercles upon it than any other form, and for this

reason it was necessary to use one organism for clover, another for peas, and so on. This preparation, nitragin, has been used with varying success abroad. Some experiments seemed to show that it was of the greatest value, while others were complete failures in demonstrating its worth. The failures so far outnumbered the successes, however, that its manufacture has been abandoned, and it can no longer be obtained. A few attempts have been made to use these cultures in this country, and while some very satisfactory results were obtained, the number of failures was even greater than abroad, the varying conditions involved in transportation and the length of time which elapsed before the germs could be used being fatal to about 80 per cent. of the material imported.

IMPROVED METHOD OF INOCULATION.

A little more than a year ago the investigation of these nitrogen-fixing bacteria was begun in the Laboratory of Plant Physiology of the Bureau of Plant Industry, with the hope of discovering some method of artificially inoculating soils which were devoid of the proper organisms, and of ensuring their producing the desired result. It was soon found that the method in use by the German investigators was not adapted to the life of the organism; that is to say, the use of rich nitrogenous food material, such as decoctions of the host plant, was not calculated to produce an organism which would fix free nitrogen from the air. It was found that, while the bacteria grew luxuriantly upon such media, they became less and less active, until eventually they lost completely this nitrogen-fixing power. It seemed as though the large amount of nitrates in the media upon which they were grown made it no longer necessary to draw nitrogen from the air, and consequently they deteriorated until they became of no more value than the common soil forms. It has been found, however, that by gradually reducing the amount of nitrogen in the culture medium it is possible greatly to increase the nitrogen-fixing power of these germs, and that by proper manipulation their activity may be increased from five to ten times that which usually occurs in nature. Practical field experiments have shown that of two cultures, one grown on nitrogen-free media and the other on a medium rich in nitrates, the first will produce abundant tubercles, while the latter will be absolutely worthless and fail to produce a single nodule.

DISTRIBUTION AND METHODS OF USE OF CULTURES.

Having secured an organism which was able to fix such a large amount of nitrogen, it was necessary to devise some means of preventing this property being lost, as well as to enable the cultures to be distributed in sufficient quantity to be of some practical use. It is now known that the bacteria when grown upon nitrogen-free media will retain their high activity if they are carefully dried out and then revived in a liquid medium at the end of varying lengths of time. By using some absorbent which will soak up millions of the tubercle-forming organisms and then by allowing these cultures to become dry, the bacteria can be sent to any part of the United States, or the world for

that matter, and yet arrive in perfect condition. Of course, it is necessary to revive the dry germs by immersion in water, and with the addition of certain nutrient salts the original number of bacteria is greatly increased if allowed to stand for a short time. Frequently twenty-four hours are sufficient to cause the water in a pail to turn milky white with the number of organisms formed in that time. Thus, by sending out a dry culture, similar to a yeast cake and no larger in size, the original number of nitrogen-fixing bacteria may be multiplied sufficiently to inoculate at least an acre of land. The amount of material thus obtained is limited only by the quantity of the nutrient water solution used in increasing the germs. It is evident, therefore, that the cost of inoculating land is very small. The principal cost is in obtaining the organisms, but the methods perfected by the Department of Agriculture now make it possible to produce these at a comparatively small cost. Special facilities for increasing the culture on a large scale are being provided.

The way in which this liquid culture may be introduced into the soil varies somewhat with the character of the seed to be used and the area of the field to be treated. With large seed it is often more convenient simply to soak them in the fluid and then, after they are sufficiently dry, to sow them in the ordinary way. In other cases it is frequently more feasible to introduce the liquid culture directly into the soil. This may be done by spraying, or perhaps a simpler method is to mix the culture thoroughly with a wagon-load of earth and then to distribute and harrow this in just as a fertilizer would be handled. Inoculations of this character have been tried on a large scale in practical field experiments, and the results have been so satisfactory that the Department of Agriculture will probably soon be able to begin the introduction of cultures into such localities as are now deficient in tubercle-forming germs. It should be borne in mind that such inoculations are usually not necessary in soil that is already producing tubercles. While the introduction of fresh organisms will generally considerably increase the number of nodules, the effect upon the crop is not appreciable, and it is hardly worth the expenditure of time and labour necessary to make the inoculation. Wherever legumes that fail to produce tubercles are being grown, however, or in those localities where the soil is so poor that legumes will not grow and because of the lack of the proper organisms they can not make a start, every effort should be made to get the bacteria into the soil.

The following notes, containing more recent information on this important subject, appeared in the seventh and eighth Annual Reports of the United States Secretary of Agriculture, the former of which was published in the *Yearbook* of the U. S. Department of Agriculture for 1903:—

The fact that leguminous crops, like peas and clover, can obtain nitrogen directly from the atmosphere when certain bacteria are present on the roots has been known for a long time, and many attempts have been made to cultivate and use these bacteria in agricultural practice. Attention has been

called in past reports to the progress the Department has made in investigating this problem. At the time of the last report the reason for the failure of former work from a practical standpoint, both in America and in Europe, had been determined, and a new, simple, cheap, and thoroughly satisfactory method of cultivating, distributing, and using these nitrogen-gathering organisms for all important crops had been perfected. During the past season the value of these bacteria has been demonstrated in extensive field tests. Good stands of clover and alfalfa, vetch, cow peas, etc., have been secured in soils where, without the bacteria, these crops were a failure. The field work also demonstrated that soil inoculation and seed inoculation are equally valuable, so that either method may be used according to convenience. As a result of these experiments, the Department is now prepared to furnish, in reasonable quantity, organisms for all the principal leguminous crops. Patents have been applied for, covering all the processes used, in order to make them secure for general public use. To enlarge the scope of this work and to carry on the necessary field demonstrations, an increase in the funds of the plant physiological and pathological investigations has been included in the estimates.

Extensive practical tests were made the past season with nitrogen bacteria for use in connexion with the leguminous crops. Results have been even more successful than was anticipated. The several strains of bacteria sent out from the Department have proved very valuable even on soils containing the uncultivated organism in abundance. The material for inoculating an acre of soil costs the Department about 1 cent per acre and the farmers scarcely anything to apply it. The demand for the organism is constantly increasing.

CHEMICAL NOTES ON 'BASTARD' LOGWOOD.*

The following notes, by Messrs. Benjamin C. Gruenberg and William J. Gies, were reproduced in the November issue of the *Bulletin of the Department of Agriculture*, Jamaica, from the *Bulletin of the Torrey Botanical Club* of July 1904 :—

During the past few years the growers of logwood in Jamaica have been greatly disturbed by an apparent increase on their properties of an unmerchantable variety of the plant known as 'bastard' logwood. † The exportation of this wood along with real logwood has served to condemn all the logwood from the districts which have shipped it.‡

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* From the New York Botanical Garden, New York. Some of the chemical work was done in the laboratory of physiological chemistry of Columbia University.

† Fawcett : *Bulletin of the Botanical Department*, Jamaica, 1896, p. 179.

‡ Clipping from a Kingston, Jamaica, newspaper, sent to Dr. D. T. MacDougal by Mr. William Fawcett (September 1901).

'Bastard' logwood differs from the genuine varieties, from the dyer's standpoint, in yielding little or no hematoxylin, but instead a yellowish-green pigment which is of no value and which, when admixed with the commercial extract, reduces the characteristic tinctorial properties of the latter. Chips of the 'bastard logwood present a yellow, pale-pink, white, or even chocolate-coloured surface instead of the dark-red or deep-purple, bronze-tinted colour of the best Jamaican or Mexican logwoods of commerce. There appears to be considerable uncertainty, even when the trees are cut down, as to whether the tree is really a 'mulatto' ('bastard') tree or not. What is known as a 'mulatto' tree is frequently dark enough when first cut to lead one to believe that it is a good red-wood tree, but instead of darkening with age as all the good wood does, it remains the same colour or becomes lighter rather than darker. The 'bastard' tree seems to be perfectly dry, and even when the chips are soaked for a long time in water, they give out no dye.*

Various theories have been advanced to explain the apparent increase in the 'bastard' logwood in Jamaica. Professor F. S. Earle, after a thorough study of the situation in Jamaica, came to the following conclusions:—†

1. 'Logwood is a variable plant showing marked differences in form, colour, and texture of leaf; time of blooming; form and extent of ribs on the trunk; colour of bark, and especially in the colour and dye-producing quality of the heart-wood. Four well-marked varieties are said to be recognized in Honduras and three are usually recognized in Jamaica, but there are many other intermediate forms.

2. '"Bastard" wood is not the result of disease or of any lack of vigour. The trees producing it are perfectly healthy and normal.

3. 'It is not the result of soil or climatic conditions, since "bastard" and normal trees are found growing side by side under absolutely identical conditions.

4. 'It is not the result of immaturity. Aged trees may produce "bastard" wood, while in normal trees the heart-wood, as soon as formed, contains a good percentage of hematoxylin. These facts seem to point to heredity as the probable cause of the trouble. That is, that certain trees produce only "bastard" wood because they grow from the seed of a "bastard" tree; or, in other words, that "bastard" logwood represents a variety of *Haematoxylon campechianum* that normally produces little or no hematoxylin, just as one Honduras variety has smaller, shorter, thinner and lighter-coloured leaves.'

Some time before Professor Earle made his investigations in Jamaica, we began, at Dr. Mac Dougal's suggestion, a comparative study of logwoods from that island, in the hope of

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* W. Cradwick: Report to the Chairman of the Experiment Station, Kingston, Jamaica (April 4, 1902).

† Earle: *Journal of the New York Botanical Garden* 4: 3, 1903; reprinted in *West Indian Bulletin*, Vol. IV, pp. 1-9.

finding definite chemical differences, other than purely tinctorial ones, between 'red' logwood and the 'bastard' variety. Unfortunately our work in collaboration was soon unavoidably interrupted. We present here very briefly, however, such of our notes in this connexion as may be of general interest.

Elementary Composition of Heart-wood.

Elementary analysis of typical samples of (1) the red logwood of commerce, (2) a 'bastard' variety somewhat resembling it, and (3) a second specimen of the 'bastard' type yielding hardly any pigment to water, gave the following results :—

Table I.—Percentage elementary composition of substance dried to constant weight at 110° C.*

	(1) 'Red' Logwood.			(2) 'Bastard' (medium grade).			(3) 'Bastard' (poorest quality).		
	C†	H	Ash	C†	H	Ash	C†	H	Ash
1.	51·91	5·98	1·80	51·45	5·83	1·59	51·04	5·67	2·03
2.	52·00	5·80	2·06	51·77	6·03	1·68	51·35	5·74	1·86
3.	52·12	5·06	1·71	51·45	6·03	—	51·00	5·58	—
Av.	52·01	5·84	1·86	51·56	5·96	1·63	51·13	5·66	1·94

Summary of Averages.

	(1)	(2)	(3)	General average.
Carbon	52·01	51·56	51·13	51·57
Hydrogen	5·84	5·96	5·66	5·82
Ash	1·86	1·63	1·94	1·81
Oxygen‡	42·15	42·48	43·21	42·61

* Only heart-wood was employed in this work. This was converted into sawdust and only such portions as passed through a very fine sieve were taken for analysis. The methods of analysis were those which are now in general use.

† The figures for carbon and hydrogen are calculated (from the data of direct analysis) for *ash-free* substance.

‡ Calculated, by difference, for *ash-free* substance.

The most significant feature of these results is the decreasing amount of carbon in the 'bastard' wood. The differences are too slight to warrant any emphasis, but are such as might be due to a lower percentage of hematoxylin, which is a pigment of high carbon (and low oxygen) content—$C_{16}H_{14}O_{6}$.

The data of the second series of analysis, given in Table II, show that the wood was not decomposed in the process of drying to constant weight at 110°C. (first series) and that, therefore, the previous results were not influenced by that procedure.

TABLE II.—PERCENTAGE ELEMENTARY COMPOSITION OF SUBSTANCE DRIED TO CONSTANT WEIGHT AT 20° C.

	(1)			(2)		
	C.	H.	H_2O.	C.	H.	H_2O.
1.	46·90	5·40	7·95	46·58	5·28	7·97
2.	46·98	5·24	—	46·87	5·45	—
3.	47·08	5·20	—	46·58	5·45	—
Average.	46·99	5·28	7·95	46·68	5·39	7·97

GENERAL COMPOSITION OF SEEDLINGS.

In Table III we present the results of some analyses of seedlings of 'red' logwood and of the 'bastard' variety. The outward appearance of the two kinds of seedlings at the time of analysis was practically the same. Likewise, the differences among the figures in our table for general chemical composition are too slight to warrant any other conclusion than that the seedling metabolism was, in general, essentially the same in both varieties. The analyses were made twelve months after the seeds were planted.

TABLE III.—GENERAL COMPOSITION OF LOGWOOD SEEDLINGS.*

		Water.		Solids.					
				Total.		Organic.		Inorganic.	
		Red.	Bastard.	Red.	Bastard.	Red.	Bastard.	Red.	Bastard.
Leaves,	*a*	{60·33 {59·89	60·05 —	{39·67 {40·11	39·95 —	{37·08 {37·70	36·93 -	{2·59 {2·41	3·02 —
	b	56·27	51·22	43·73	48·78	41·08	45·94	2·60	2·84
	c	63·57	60·68	36·43	39·32	34·72	36·50	1·71	2·82
Upper stem,	*a*	43·77	38·34	56·23	61·66	54·40	58·29	1·83	3·37
	b	39·06	34·01	60·94	65·99	59·08	63·99	1 86	2·00
	c	43·68	45·89	56·32	54·11	54·61	52·50	1·71	1·61
Lower stem,	*a*	43·19	39·99	56·81	60·01	55·62	58·32	1·19	1·69
	b	36·83	32·97	63·17	67·03	61·63	65·24	1·54	1·79
	c	43·39	44·46	56·61	55·54	55·41	54·14	1·20	1·40
Roots,	*a*	67·93	61·66	32·07	38·34	30·52	35·39	1·55	2·95
	b	65·32	70·58	34·68	29·42	33·20	27·70	1·48	1·72
	c	—	49·17	—	50·83	—	46·87	—	3·96

CONCLUSIONS FROM THE GENERAL ANALYTIC DATA.

All of the preceding analytic results make it evident that the chemical differences existing among these logwoods are quantitatively very slight. They also make it appear probable that the variations in the different samples of the wood are chiefly variations in the chemical characteristics of the pigments themselves, which, as is well known, possess, as a rule, high tinctorial qualities even when they occur in only very small amounts. Our results in this connexion would also indicate that there are no structural differences among these varieties of logwood. They suggest, likewise, that even metabolic tendencies in these logwoods are essentially the same, varying only, perhaps, in the course of events which involve relatively slight quantities of pigment.†

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* Analyses were made by the usual drying and incineration methods. The portions subjected to comparative analysis were approximately of the same morphological location in each variety. The most significant differences seem to be the slightly larger proportion of water in the 'red' wood and the relatively greater quantity of solids, especially inorganic matter, in the 'bastard' samples.

† These conclusions are in harmony with those drawn from other standpoints by Professor Earle (quoted on p. 250). They were arrived at independently by us and were included in our report, in December 1902, to the Botanical Society of America before we were aware of Professor Earle's deductions. *Science*, II. 17 : 338, 1903.

Tinctorial Differences.

The foregoing results having shown that the differences among these logwoods were chiefly, if not solely, tinctorial, we next endeavoured to ascertain the extent of the pigmentary variations.

Our first experiments in this connexion were efforts to determine the relative tinctorial intensity of extracts of different samples of heart-wood sawdust made with equal volumes of various solvents under similar conditions of temperature, shaking, etc., from the same quantities of material dried to constant weight at 110°C.* Among the samples were several inferior qualities of red wood from dead and decaying trees.

Table IV gives our first results in this connexion. The figures in that table denote the relative positions in a series of ten extracts—1 indicating weakest colouration, 2 the pigmentation of next higher intensity, and so on to 10, showing the most decided tinctorial effect.

The shade of colour varied with each extractant, as would be expected. The following observations were made in this connexion on the colour of the series of extracts referred to in Table IV :—

I. Water—slight yellowish-brown to deep reddish-brown.†

II. 0·2 per cent. HCl—faint-yellow to orange.

III. 2·0 per cent. HCl—faint-yellow through reddish brown to bright red.

IV. 0·01 per cent. KOH—chocolate colouration throughout.

V. 0·15 per cent. KOH—deep-chocolate colouration throughout.

VI. 0·5 per cent. Na_2CO_3 —chocolate colouration throughout; less than in V. greater than in IV.

VII. Saturated borax solution—faint-yellow to deep reddish-yellow.

VIII. Ether—faint-yellow to orange.

IX. Absolute alcohol—faint-yellow to red.

X. Acetone—faint-yellow through greenish-yellow to yellowish-red.

XI. Acetic ether—faint-yellow to deep reddish-yellow; brighter than in VII.

XII. Chloroform—no colour in some, faint-yellow in others.

XIII. Benzol—no colour in any.

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* Drying occurred rapidly and seemed to have no transforming effect on the dust. This fact was noted before in another connexion (p. 252).

† The colouration intensities are indicated progressively from 1 to 10 (see table IV). Individual exceptions are not referred to.

TABLE IV.

RELATIVE PIGMENTATION OF VARIOUS KINDS OF LOGWOOD.

Extractant.	A*	B	C	D†	E	F	G	H	I	J
I. Water	1	2	3	10	4	6	7	5	8	9
II. 0·2 per cent. HCl. ...	1	2	5	7	6	3	4	10	9	8
III. 2·0 per cent. HCl. ...	1	2	4	3	5	6	7	8	9	10
IV. 0·01 per cent. KOH.	1	2	4	3	5	6	7	8	9	10
V. 0·15 per cent. KOH.	2	4	1	3	5	7	6	8	9	10
VI. 0·5 per cent. Na_2CO_3 ...	2	2	1	6	4	5	7	8	9	10
VIII. Ether	1	2	5	4	8	7	9	6	3	10
IX. Absolute alcohol ...	1	2	4	3	6	5	9	7	8	10
X. Acetone	1	2	4	3	5	9	6	7	10	8
XI. Acetic ether ..	1	2	3	4	6	7	5	9	8	10
Average ...	1·2	2·3	3·4	4·6	5·4	6·1	6·7	7·6	8·2	9·5

More important, however, than the variations in the shades of colour in the extracts was the fact, already noted, that the *sequence* of colouration intensity (in extracts made under like conditions in detail in each series) *varied* with each solvent (Table IV). This result not only shows that the colours of the woods are not due merely to different amounts of the same pigment, but also proves that the pigmentary differences are caused either by varying proportions of at least two pigments, or by the same pigment radical in more than one chemical condition—in combinations, it may be, of different solubilities and stoichiometric relationships, and of different dissociable tendencies.

Relative tinctorial differences and variations are further

*A—'Bastard' (very poor). B—'Bastard' (very poor). C—Immature wood of varying tints. D—'Purple' (from tree on extremely poor marly bank; tree mature, but dead in nearly all parts, including the roots). E—Immature wood of varying tints. F—'Bastard' (medium grade). G—Red (tap root of nearly dead tree). H—Red (tree over ripe; wood bored by ants). I—Red (from roots of dead tree). J—Red (best grade).

† This sample contained several pigments. One of these was purplish and quite unlike any in the other samples. The pigment was especially soluble in water. It was not ordinary hematoxylin.

shown in the following sample data, which indicate the quantity of water in c.c. added to 10 c.c. of 0·5 per cent. Na_2CO_3 extract (Table IV) in order to make the tinctorial intensity approximately the same throughout the series.*

TABLE V.

Sample of logwood.	Water added.	Sample of logwood.	Water added.
A	3·5 c.c.	C	7·5 c.c.
B	3·5 ,,	D†	10·0 ,,
F	5·5 ,,	H	10·9 ,,
E	7·1 ,,	I	12·2 ,,
G	7·1 ,,	J	17·8 ,,

The letters correspond to those in Table IV.

The tinctorial sequence after the above dilution is different from what it was before dilution, as may be seen from the following summary :—‡

TABLE VI.

	1	2	3	4	5	6	7	8	9	10
Before dilution (Table IV).	C	A	B	E	F	D	G	H	I	J
After diiution (Table V).	A	B	F	E	G	C	D	H	I	J

The above facts are in further harmony with the foregoing conclusions regarding cause of colouration, effects, and relative differences.

Dilute aqueous extracts of two samples of red logwood and of one medium-grade 'bastard' wood all showed a similar yellow colour by transmitted light. The shades of colour did

* Dilution of D with an equal volume of water furnished the bases of colouration or the comparative observations.

† This colour was of the same intensity as the rest, but not the same shade. See foot-note above.

‡ A similar change in sequence of tinctorial intensity after dilution was also noted in other extracts.

not differ noticeably except in degree. In stronger extracts of equal concentration the first two appeared more reddish.

Treatment with alkalies, volatile and non-volatile, turned the colour of the red logwood extracts to a blood-red passing into purple, whereas in the bastard extract the shade of yellow was merely deepened, passing into the dull-brown colour of faded oak leaves. Dilute and concentrated mineral acids turned the yellow of the dilute aqueous extracts of the red wood into a colour ranging from orange to bright-red. In the 'bastard' extract no such change was perceptible.

These differences in the behaviour of the two sets of aqueous extracts toward acids and alkalies correspond to the differences between the reactions exhibited toward the same reagents by a freshly prepared solution of the commercial 'extract of logwood,' and a solution four weeks old that had faded to a straw-yellow.

The chemical alterations undergone by the aqueous solution of the commercial extract are accompanied by such a decided change in colour and in chemical properties that from a comparative study of such extracts we expected to learn something definite regarding the actual differences between the pigments in the heart-wood of 'red' logwood and in that of the bastard variety. We were unable, however, to do so.

Experiments were started to determine, if possible, the relations of light and of air to the discolouration of solutions of logwood extracts. In a few weeks all the preparations had been attacked by growths of *Penicillium*, *Rhizopus*, and other fungi. After filtration the solutions showed no appreciable differences in shade or colour. But on diluting these filtered solutions with two parts of water and eventually with eight parts, differences were readily observed.

The solutions which had been in the light showed no change in colour, whereas those kept in the dark had become distinctly yellow. The extracts to which the air had free access manifested the greatest changes.

Solid Matter in Logwood Extracts.

We desired to ascertain, in comparative determinations, the quantities of solid matter in aqueous extracts of the various logwoods under investigation. The absolute amount of solid substance in 100 c.c. of the extract was always small—less than 0·02 gram. In the drying process slight decomposition seemed to result and perfectly constant weights could be obtained only after a long time. Although the absolute changes in weight were only very small, the proportionate variations in quantities so slight were quite large. For these reasons no comparative observations were attempted in this connexion. The use of very large volumes of extract, to reduce the comparative effects of the variations referred to, was impracticable.

The general question of the physiology or chemistry of pigment-formation in the heart-wood was not approached at all, nor were the histological characters of the varieties compared.

There can be no doubt that 'bastard' logwood is, as Professor Earle also concludes (see p. 250), a distinct variety or subspecies of *Haematoxylon campechianum*, notwithstanding the slight morphological differences that distinguish it from the 'red' logwood and 'blue' logwood.

That there are species which are not at all distinguishable from one another externally, but which vary in their physiological properties, is a recognized fact,* and the 'bastard' logwood may simply be a new example of the same phenomenon. A parallel case would seem to be furnished by the black locust (*Robinia pseudacacia*), the wood of which is described by Sargent† as being 'reddish, greenish-yellow or white, *according to locality*'; but the yellow and white varieties occur side by side in at least one locality.

Summary.

1. The most significant fact shown by elementary analysis of the heart-wood of typical specimens of logwood was the lower carbon content of the poorer wood, which may be due to lower pigment content, hematoxylin being a compound containing nearly twice as much carbon as oxygen.

2. No morphological differences are discernible between red logwood and 'bastard' logwood in the young seedlings.

3. Analyses of the various seedlings agreed too closely to warrant any conclusion but that the metabolism of the seedlings was essentially alike in the two varieties.

4. The chemical differences between red logwood and 'bastard' logwood are very slight, and are probably due to differences in amount of pigment.

5. Extractions with various solvents gave solutions of different colours, and also of varying orders of intensity in the several series, indicating the presence of at least two pigments in varying proportions, or a pigment radical in different combinations.

6. This was confirmed by the fact that the order of colouration intensity of a series of extracts was altered by diluting with water.

7. Aqueous extracts of the two varieties of logwood gave different reactions to acids, alkalies, and other reagents. The differences are parallel to those between a fresh aqueous solution of commercial logwood 'extract' and the same solution after it had become discoloured on long standing.

8. Attempts to determine the conditions of the discolourations of solutions of commercial 'extract' failed to yield definite results, but indicated, in general, that darkness and air are favourable to the change.

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* DeVries : *Mutationstheorie*, 1 : 122. 1901.

† Sargent : *Catalogue of the Forest Trees of North America*, 15. Washington, 1880.

SUGAR-CANE CULTIVATION IN HAWAII.

In view of the large yields of sugar-cane that are commonly obtained in the Hawaiian Islands, it is considered that planters in the West Indies might usefully be put into possession of information with regard to the sugar industry in Hawaii. The following extracts have, for this purpose, been carefully selected, principally from reports of Committees of the Hawaiian Sugar Planters' Association published in the *Hawaiian Planters' Monthly*, the official publication of the Association :—

The cultivation of sugar-cane and the manufacture of sugar, says a Penang planter, is without doubt more carefully studied and carried on in a systematic manner in the Hawaiian Islands than in any other part of the world.

The irrigated lowlands produce the largest crops, for the simple reason that by the regularity of the application of water the growth of the cane is a sturdy one and never suffers from dry spells. Good crops in the Hawaiian Islands produce about 126,000 ℔. of cane, or 18,000 ℔. of sugar per acre.

Most of the flourishing plantations previous to the annexation of the islands by the United States of America, which brought about a considerable rise in the price of labour, produced sugar for less than $35·00 gold per ton. Labour at that time cost about 50c. per day, while at this time it is about $1·00 gold, with a tendency to rise.

The analyses of the soil, and the application of proper fertilizers have, for the past few years been a matter of great advancement in the sugar industry.

Soil that would, without fertilizers, produce 4 or 5 tons of sugar per acre, will, with the application of suitable fertilizers, produce about double the outturn.

No expense or trouble is spared in having the soil analysed by experts, to find out what particular fertilizer would be most suitable, and what sort of cane would be likely to thrive best.

Seed is freely exchanged between the planters on the different islands. The theory of fertilizing is that it is necessary to put back into the soil just what the cane takes out of it, and in that way always keeping the soil up to par. (*Hawaiian Planters' Monthly*, July 1902.)

PLANTING AND CULTIVATION.

BREAKING AND PLOUGHING.

The methods of breaking up or tilling the soil for seed-bed are varied, depending on locality and depth of soil. On Oahu Maui, and Kauai steam-ploughs are chiefly used, but only a few sets on Hawaii, as that island has only a limited area of land adapted for steam-ploughing. The capacity of steam-ploughs ranges from 10 to 15 acres per day ploughing a depth of 1 foot to 2 feet according to requirements. In districts with light soils where animals are used for ploughing the old style of hand-plough is fast being replaced by the latest design of

'Sulky' and 'Disc' ploughs. In the Hilo district most of the round ploughing was formerly done by light wheel walking ploughs drawn by three animals, cutting a furrow of from 12 to 16 inches, about 9 inches deep, and ploughing about $1\frac{1}{2}$ acres a day. The 'Disc' plough has now become the favourite and a number of planters use it exclusively, claiming better results from the more complete pulverizing of the soil, and especially from its adaptability to throw any extra depth of furrow or subsoil directly on the surface with increase of exposure to atmospheric influences. Several designs of harrow are now in use for the tilth of our soils before furrowing, but the 'Spike' or 'Drag' harrow is more generally used than any other.

FURROWING.

The land is furrowed on an average about 5 feet apart, and the depth of the furrow depends on the amount of surface soil or vegetable mould. Some furrow-ploughs are entirely too heavy and clumsy, and could be greatly reduced and improved. The handles of the ordinary furrow-plough are too high and too short. A change in a furrow-plough came under our notice this year that had been reduced in weight 190 ℔., the handles made longer, and, instead of fastening them on end of beam, were lowered by placing them in the body of the plough, and so giving to the operator more purchase over the plough. There is just as much economy in saving manual labour and mule-power in the fields as steam in the mill.

Various implements are in use to loosen up the seed-bed after the furrow-plough, viz., sub-soiler, small-plough, small-harrow, or cultivator. The Hilo Sugar Company use two sections of a stubble-digger to revolve in the bottom of the furrow, fitted on a small frame with handles, and drawn by one animal, the implement stirring up the bottom of the furrow to a depth of 6 inches. At Onomea there is another device for this work ; two small sub-soiler discs, of about 14 inches diameter, are attached, face inwards, to a small sub-soiler and drawn after the furrow-ploughs, thereby widening the furrow and leaving an excellent bed for seed-cane. (Ibid., December 1902.)

PLOUGHING.

Now, with respect to the depth at which they plough, when you are discussing Hawaii and the planting of sugar in those islands you have to take into consideration that there are two distinct classes of planters on the islands ; one class on the windward side, where there is an abundance of rain, (sometimes too much); the other on the leeward side of the island, where they have no rain, and consequently irrigate. The two customs of planting, preparation of soil, etc., are therefore entirely different. On the windward side they plant similar to us in Louisiana; they prepare the lands with ploughs and they have rows uniformly 5 feet wide all over the island. I found the rows nowhere wider than this. It seems by universal consent they have come to this width. On the leeward side of the island I had the good fortune to see them plough. They break the land with steam ploughs—five-gang ploughs. The one I saw was running 3 feet deep—a tremendous

depth. They were ploughing and breaking the soil, pulverizing it very finely. I will have to say, however, in order that you may appreciate this fact, that their lands are volcanic, and do not possess that plasticity that ours do. In other words, you can get a very good idea of their soils if you will take our ordinary brack-bats and pulverize them. It is well known that when you take pulverized bricks and analyse them, they have lost their plastic properties; they never run together. Therefore, their soils being volcanic, emitted in the melted condition, disintegrate either naturally, through the ordinary methods of watering or through some agent which I need not stop to explain here, which is emitted along with the rock. These soils disintegrate and form a powder very similar to pulverized brick-bats, and therefore do not run together at all—do not break up into lumps, but pulverize prettily. Having ploughed in this way, they lay the rows along the lines of levels. Contrary to public opinion here, or away from the island, the sugar lands in Hawaii are by no means level. They roll very rapidly from the sea-coast upwards. Now, they lay off rows, 5 feet apart, and use a double-decked mould-board plough, drawn by eight mules. They lay the rows off 5 feet apart and they go 30 to 32 inches deep—they plant cane this depth, using the tops of the cane, which is planted in one continuous row of tops. As soon as they are planted, a little stream of water is turned on the cane, and right behind come Chinese with hoes, who draw a little dirt about 2 or 3 inches over the cane, and in six days the cane came up making a good stand. I saw that accomplished while I was there. That is the method of preparing the land. Irrigation is continued, and after each irrigation the hoe follows and draws a little dirt over the cane. Water is one of the great troubles they have over there; hence they have to be very economical in its use. They irrigate with a stream of water, at each irrigation, which you would laugh at here. It is a little trickling stream—a small rivulet trickling down the centre of the rows. The Chinese come immediately behind it and draw the dirt over it in order to conserve the moisture. As fast as one row is laid, the water runs immediately after it. That is the method of preparation for planting on the leeward side. On the windward side, they do as we do. They put the cane in slight ridges. I may also remark just here, that that soil is perfectly porous and that the rains falling upon it from the mountain side penetrate it immediately—it goes right down. (Professor Stubbs' description of cane planting in Hawaii: Ibid., December 1900.)

In this territory we have localities which suffer periodically from droughts, and plantations which receive rain to spare. We have high temperatures and the reverse. We have lands that are extremely rocky; others without a stone on them. We have flat plains in one place and lands crossed by gulches, varying in depth from 20 feet to 1,000 feet. We have windy districts and districts with no wind. We have rich soils and poor soils, deep soils and shallow soils. In fact, we have every tropical cane-growing condition to labour under, Thus Mr. A. Moore, of Kilauea, in a letter to your Committee

practically voiced the experience of all the managers of Hawaii when he said: 'Each plantation has its own conditions to govern its work, the manner of doing it and its cost.'

Your Committee forwarded fifty-two circulars to the plantations of this territory and received thirty-six replies; nineteen of these were from irrigated plantations, and seventeen from non-irrigated plantations, classified as follows:—

From Irrigated Plantations.	From Non-irrigated Plantations.
6 on island of Oahu	16 on island of Hawaii
4 ,, ,, ,, Maui	1 ,, ,, ,, Maui
9 ,, ,, ,, Kauai	
Total 19.	Total 17.

PREPARATION OF THE SOIL.

This may be briefly summarized by the statement that the general practice is to plough as deep as possible, either loosening the subsoil below or without turning up much of it. Where lands are rocky or difficult to handle otherwise, the 14-inch breaker is generally used; where the lands are not so hilly, the disc plough is in general use; and where fields are broad and fairly flat, as in the middle portion of Hamakua, the western end of Kohala, and on irrigated plantations, steam-ploughing implements of 'Fowler' make have been found the most profitable. Briefly summarized, the results from thirty-six replies to circulars received are as follows:—

20 plantations use steam implements
5 plantations use breakers principally
11 plantations use disc ploughs with subsoil attachment principally

Total 36.

Your Committee refers you to a very valuable communication from Mr. Jno. M. Horner, of Hamakua, which is appended to this report on the advantages of the 'disc' plough. From data received from different managers, the 'Secretary' disc plough is used in Hilo and Kohala, and the 'Venicia' disc plough in Hamaqua. The main thing to be noticed is the application of the 'disc' in annual ploughing, wherever practicable, instead of the old-fashioned mould board. It lightens the drought and breaks up the soil better. Will someone say why the 'disc' principle cannot be carried out in our steam-ploughing implements in place of the old-fashioned mould-board? Ten or twelve years ago there was not a single disc plough in Hawaii; now they are being used wherever circumstances permit, and it would appear that if the principle is the same the adoption of the 'disc' in steam implements on lands free from rocks is merely a question of strength and material. At any rate, the question is worth looking into. On the plantations of Waialua, Oahu, and Ewa there has been introduced a large implement used in second ploughing called the 'Oliver' plough. This is a 30-inch plough attached to the 'Fowler' steam apparatus. Where the soil is deep and free from stones, this does excellent

work, reaching to a depth of from 28 to 30 inches. This sort of second ploughing is expensive. A set of 20 horse-power 'Fowler' ploughs, with this implement, goes over but 5 acres or so per day. At the same time, the results obtained fully justify the extra cost. At Ewa, the highest yields ever obtained from certain fields were those ploughed to a depth of 30 inches with the 'Oliver' plough.

It is a striking fact that all of the plantations, where the nature of the land will allow, use steam-plough implements in the preparation of their soils. It undoubtedly costs much more than animal ploughing, but the soil is in so much better condition, and the return per acre so much enhanced that their use is of great financial benefit. (Ibid., December 1903.)

PLANTING.

The general method of planting is to place the seed in the furrow by hand, butt to butt, and covered to a depth of from 2 to 3 inches. Many amusing notions still hold sway in the planting season. Some prefer the top of the seed left uncovered to keep the seed alive; others demand the seed planted whichever way the wind mostly blows. In Hamakua this year, a Japanese company threw up a co-operative contract on the ground that the seed was not planted so that it would grow the prevailing way of the wind. Suffice it to say, that the young plant from this doomed seed is as far advanced to-day as the plant from seed of supposed more favoured conditions.

The question of cultivation by animals between the cane rows is still much discussed. We firmly believe that wherever it is practicable, cultivation between the rows should be done with cultivators drawn by mule-power. A man and a mule with a cultivator or small plough can perform as much work as ten men with hoes. It seems, therefore, fair to assume that this matter of detail should have careful attention, and especially at a time like the present when labour is very scarce, and the market for sugar ruling low. On nearly all un-irrigated plantations the land is freely stirred up and weeds controlled between the young cane rows by mule-power; the exceptions are on those plantations where stony ridges and other conditions make it impracticable to place animals in the young crop. Some planters still contend that using small ploughs in young plants is detrimental because they cut off too many young roots. But in rainy districts, where cultivation with small ploughs has been adapted for many years, it is now generally conceded that mule cultivation is most beneficial to young cane in that it thoroughly loosens up the soil for the cane roots to spread in, and improves the condition of the soil by frequent exposure to sun and atmosphere. A small plough of about 8 inches cut, and drawn by one animal, is considered the best size for cultivation in young cane. In addition to the ordinary cultivator and V-shaped harrow, there is the 'Horner' cultivator, now much in use, and especially in the Hilo district where weeds grow in the night. The principle of this cultivator is different to that of the ordinary implementss According to the quantity of weeds to be handled it drags

them into piles about 20 or 30 feet apart, thereby concentrating the weeds over a much smaller area than if left scattered over the entire row as happens with the ordinary cultivator. We might make mention of another labour-saving implement, and for the purpose of this report we will call it the 'Hiller.' This is a device for throwing earth to the young cane. It is shaped like a snow-plough, and makes an excellent finish to a field of young cane when the growth is such as about to cover the rows. Mr. Albert Horner (Kukaiau) has been experimenting this year with a new implement for hilling ratoons. It consists of two 16-inch discs placed on either side of a goose-necked beam, and with a subsoiler attached behind to loosen the narrow rim left by the discs in the centre of the row. The implement is drawn by three animals, and operated by one man. This season Mr. Horner has hilled up all his ratoons with this implement, and we can certify that it makes far superior work to the ordinary method of hand-plough and harrow. The soil is thrown up to the cane in a finely pulverized condition; and also there is a saving of labour in that one turn of the implement in each row completes the operation. (Ibid., December 1902.)

In the Hilo and Hamakua districts furrows are run, as a rule, from 5 feet to 6 feet apart, and in Kohala 4 feet 6 inches apart. In other parts of the territory the average is $5\frac{1}{2}$ feet. This last spacing applies also to irrigated plantations. Tops are everywhere preferred for seed, and where these cannot be obtained, either plant or good first ratoons are used, depending in either case upon the appearance of the cane, and the development of the bud. Seed, in general, is cut from 8 to 12 inches in length. The greatest difference to be noted is in the placing of seed canes. In one district this varies from 'overlapping' to setting 8 inches apart. In general, it may be said that in the poorer mauka or rocky soils, with heavy rainfalls, seed is overlapped, and that in localities of lesser rainfall or possibly richer soils, seeds are placed either end to end or several inches apart, depending upon quality of seed, soil, and season of the year. With an early plant in the warm months of June and July seed is, as a rule on irrigated plantations, spaced a few inches apart. Germination is then at its best, and there are fewer 'misses' which can be replanted in good season. But, as a rule, the later seed canes are placed end to end; or, if very late in the season, overlapped so as to ensure a good stand, an even start, and to avoid replanting. (Ibid., December 1903.)

STRIPPING.

The removing of dead leaves from the cane, generally called 'stripping,' is a process in our cultivation that is very essential for the proper development of a cane crop. Where the crop is not exposed to drought for a long period, the best results are usually obtained from cane stripped some months prior to harvesting. Stripping also reduces the amount of destruction caused by borers, rats, and other pests; lessens the cost of cutting and allows of sending cane to the mill free form a coating of dry leaves, which is very much against good extraction. (Ibid, December 1902.)

The pros and cons of this have probably been as much discussed in the Association as any other portion of the industry. On the Island of Hawaii, with not as a rule an extra heavy growth of cane, so that for two strippings the entire cost runs from $10·00 to $15·00, and because of the rainy weather, especially in Hilo and portions of the Hamakua district, the managers are unanimously in favour of stripping. When, however, we come to consider the question from the view point of the irrigated concerns, where the districts are generally known as 'dry,' and where the cost of stripping is much greater and frequently double that of Hawaii, there is not the same unanimity of opinion. Seven out of sixteen irrigated plantations, from whom replies were received, do not strip their canes. The remainder advocate stripping for various reasons. It would appear to your Committee that where the expenditure for stripping per acre is as large as it is on some of the irrigated concerns, this matter might well be tested at the Experiment Station for the purpose of obtaining data on the subject. This test, of course, would not settle the question for all plantations on account of differences in local conditions, such as temperature, slow or quick ripening, rainfall, insect pests, etc. But the results certainly would provide food for thought and be a forerunner of tests at each plantation to settle this important question.

RATOONING.

In the matter of long ratooning, the great preponderance of opinion is, that they are as profitable as plant cane, especially on irrigated lands. From but eight plantations out of thirty-six have we received word that ratoons are not considered as profitable as plant cane. On the other hand, the weight of evidence is against short ratoons as opposed to cutting back. Of course, there are conditions and circumstances where short ratoons become profitable. One is cited by Mr. Stodart, of the McBryde Sugar Company, where 560 acres yielded 4·44 tons sugar per acre, which was probably exceptional. Of these conditions, each manager can be the one to judge.

HILLING UP.

The matter of hilling up irrigated ratoons is in general favour on Kauai and Maui. At an average given cost of from $4·00 to $6·00 per acre, the estimated returns are from $\frac{3}{4}$ ton to $1\frac{1}{2}$ tons of sugar per acre. This is a large return for a small expense. This operation is not yet practised to any extent on Oahu except at one plantation. Experiments are being made at one other. The operation consists in ploughing deeply and loosening soil between the furrows with a 10-inch plough pulled by two mules, hitched tandem, and followed by the spreading of the loose, ploughed earth against the canes by means of a V-shaped machine; the ratoon canes are thus on the hilled portion and water is applied in the hollow space between the cane rows. It would appear to your Committee that where the atoon furrows are shallow, hilling up is an excellent method o adopt, but that where the furrows are deep, the advantages are not so manifest. In an experiment, carried out at Ewa

with cane 2 feet high, a large portion of the stalk was buried, owing to the depth of the furrow. This experiment, however, will not be completed until the cane is ground and results known.

IMPLEMENTS AND CULTIVATION.

The general practice is to use cultivator and horse plough in the Hilo district, and, on account of excessive rainfall, to fill in furrows and to hill up plant canes as fast as circumstances permit. In those districts of lesser rainfall and occasional drought, such as Kohala and the western portion of Hamakua, the general practice is the reverse of that in Hilo. On this subject Mr. Forbes, of Kukuihaele, writes as follows: 'Do not believe in filling in plant furrows, for just as much as we fill in, that much more we have to hill up on ratoons. Then, when the evil day of drought comes, those canes which are rooted high are the first to suffer, as the hilled up part dries quicker than if, say, moderately level. Naturally, when hilled up there are surface roots encouraged by the soil being forced around the stem.' In ratooning on plantations not irrigated, the endeavour is to plough as deeply as possibly between the cane rows, using either the Venicia disc ratoon plough or one of the ordinary make, in order thoroughly to loosen up the soil. No special implement or set of implements is used in all cases in ratoon cultivation, owing to differences in local conditions. Where, however, the soil is free from rocks, Horner's cultivator is spoken of highly as a tool for freeing the land of weeds at low cost. (Ibid., December 1903.)

MANURING.

In intensive agriculture, such as is practised on these islands in the growing of sugar-cane, the question of fertilization must needs be a very important one. Owing to the wide diversity of conditions with regard to climate and soil which characterize the sugar lands of this territory, it becomes manifest that the subject of fertilization is one which must be worked out in large measure for each individual plantation. Not only must the needs of the crop be taken into consideration and weighed with relation to the quantity of plant foods stored up in the soil, but the forms in which the various fertilizing ingredients must be added to the soil to render the best service constitute a subject of equal importance.

The financial loss which may accrue from the improper use of fertilizers does not merely include money expended on fertilizers which do not give increased yields of sugar per acre, but added to such amount is the cost of labour in applying such material to the soil. Again, in the utilization of the waste products of the mill and stables, which would otherwise be discarded, the loss involved would be the resulting difference in yields following the rational and irrational application of such material. That fertilizers pay, and pay well, when judiciously applied, has long been demonstrated on these islands and much has been written on the subject and presented in former reports. In this report it is our desire to give an idea of the amounts and commercial value of fertilizers applied during the growth

of a crop, and to indicate in a measure some of the ways in which a part of the money so expended might not be in the most full accordance with economy.

The data received from plantation managers have yielded the following approximate figures :—

The amounts of purchased mixed fertilizer applied per acre varied from 400 ℔. to 1,700 ℔.

The variation in the potash content of this material was from 4 to 21 per cent. ; phosphoric acid, 3½ to 15½ per cent. ; nitrogen, 4·1 to 9 per cent.

The average amount of mixed fertilizer applied was 850 ℔. per acre ; and of nitrate of soda, 159 ℔.

The crop of 1902 was harvested from approximately 79,000 acres.

The mixed fertilizer used for the crop approximated 33,575 tons.

The nitrate of soda used for the crop approximated 6,280 tons.

The average formula of the mixed fertilizer was 6 per cent. nitrogen, 8 per cent. phosphoric acid, and 9 per cent. potash.

Nitrogen in mixed fertilizers applied	2,014 tons.
Phosphoric acid ,, ,, ,, ...	2,695 ,,
Potash ,, ,, ,, ...	3,290 ,,
Nitrogen in nitrate of soda	942 ,,

The value of these elements would be very much as follows :—

Nitrogen in mixed fertilizer	$604,200
Phosphoric acid ,, ,, ,, ...	215,600
Potash ,, ,, ,, ...	312,550
Total value of mixed fertilizer	$1,132,350
Nitrogen in nitrate of soda	282,600
Total	$1,414,950

In addition to the amount of mixed fertilizer and nitrate of soda applied, about 1,500 tons of tankage, 800 tons of ground coral, and 2,000 tons of bone meal were used. The value of this large quantity of fertilizing material, together with the cost of mixing, bagging, freight, and manufacturer's profit would probably bring the total cost to about $1,700,000.

It is seen that the value of the element nitrogen in mixed fertilizers applied during the past crop was greater than that of the other elements combined, being $604,200 against $528,150, the total value of potash and phosphoric acid used. Unfortunately the most expensive of the fertilizing elements is the one which, under certain conditions, is most liable to waste. (Ibid., December 1902.)

POTASH.

With respect to potash, the tendency has been to increase the percentage of this element in mixed fertilizers during the last couple of years, and favourable results following such change are reported from a number of plantations. Mr. Pullar, of the Committee, writes:—'We have increased the potash content the past two years with good results and it ought to be higher yet, I think.' The sugar-cane is a great potash feeder, a fact which has been amply demonstrated by the chemical analysis of its ash. The average amount of potash used per ton of sugar grown with fifteen varieties of cane at the Experiment Station was 150 ℔. The combined weight of the other so-called vital elements, nitrogen, phosphoric acid, and lime, taken up by the cane averaged 101 ℔. per ton of sugar. Of the three varieties of cane, Lahaina, Rose Bamboo, and Yellow Caledonia, which are most commonly grown on these islands, the average amount of potash taken up per ton of sugar produced was found to be 111·6 ℔. Of this amount about one-third would go to the cane stalk and two-thirds to the leaf, a difference in requirements which is a most fortunate circumstance, for through ploughing into the soil or burning the strippings and waste matters of the cane field, large amounts of this element are conserved for future use. Most of the potash applied in fertilizers for the last crop was in the form of sulphate, very little being used as muriate. The cost of the two forms is slightly in favour of the muriate, although under most conditions on these islands the sulphate must prove the more economical of the two, through its superior fixing qualities and its smaller depleting action on the lime of the soil.

PHOSPHORIC ACID.

While the tendency has been to increase the percentage of potash in mixed fertilizers, the phosphoric acid in many cases has been materially reduced. Phosphoric acid has one advantage over other fertilizing ingredients through its power of readily becoming fixed in the soil, and very little of this element applied in its most soluble form can be lost from the land during heavy rains or irrigation. When used in a soluble form in larger amounts than is required, through its insolubility following fixation, the excess remains in the soil to be drawn upon by future crops, and the soil is correspondingly enriched as regards the material. While indispensable to the cane, it is withdrawn in smaller quantities from the soil than is the case with the other fertilizing elements, about 15 ℔. per ton of sugar being the average requirement for Lahaina and Rose Bamboo cane at the Experiment Station. The cane and leaves divide the amount in almost equal proportions, so that a large percentage is returned to the soil after harvesting the crop. Unlike potash, however, the amount which is returned to the soil through the burning of the refuse of the field is chiefly in an insoluble form and does not possess any particular fertilizing value. Hawaiian soils as a rule stand high in phosphoric acid, but the element is locked up in insoluble forms. The object of adding phosphoric acid to the land, then, is not so much for

the purpose of increasing the total stock of this element—such an increase would be infinitessimal—but to increase the amount which will be available for the crop. (Ibid, December 1902.)

Circular letters containing questions relating to fertilization were sent to the managers of the various plantations, and the answers received furnished some very interesting statistics and information regarding the use of fertilizing material in these islands. As similar data were obtained last year by the Fertilization Committee, it may be of interest to bring figures into comparison, which represent the value and quantities of fertilizer used for the last two crops.

The average quantity of mixed fertilizer applied per acre for the crop of 1902 was 850 ℔., and for 1903, 910 ℔.

The average formula for the two years was as follows:—

	1902.	1903.
Phosphoric acid	8·0 per cent.	7·1 per cent.
Potash	9·0 ,, ,,	10·1 ,, ,,
Nitrogen	6·0 ,, ,,	6·1 ,, ,,

The crop of 1903 was harvested from about 90,000 acres, and the total quantity of mixed fertilizer applied was approximately 41,000 tons.

The amounts of nitrogen, phosphoric acid, and potash in this quantity of material were as follows:—

Nitrogen in mixed fertilizer	2,501 tons
Phosphoric acid ,, ,, ...	2,911 tons
Potash ,, ,, ...	4,141 tons

About 6,000 tons of nitrate of soda, containing approximately 900 tons of nitrogen, were also used.

These large quantities of the various fertilizing ingredients would have values somewhat as follows:—

Nitrogen in mixed fertilizer ...	$750,300
Phosphoric acid ,, ,, ...	232,880
Potash ,, ,, ...	393,395
	$1,376,575
Nitrogen in nitrate of soda ...	270,000
Total ...	$1,646,575.

In addition to nitrate of soda, special fertilizers such as lime, ground coral, fish scrap, muriate of potash, tankage, and a mixture of nitrate of soda and sulphate of ammonia were also applied. The value of these latter materials, together with the cost of bagging, mixing of complete fertilizers, and transportation, would bring the total amount expended for fertilizers to somewhat over $2,000,000

The large amount of capital annually expended for fertilizers in these islands, together with the fact that other sugar-producing countries use very much less fertilizing material, would naturally cause one to consider if the large cost of fertilization in this territory is justified by the increased returns. The average cost of fertilizer used per ton of sugar produced

would approximate $4·65, and per acre $22·20. To pay for the cost of fertilization for the crop of 1903, there must have been at least a gain of 28,571 tons of sugar for the islands, or 635 ℔. on an average per acre. An increased production of 635 ℔. per acre would represent a gain of about 7 per cent. There is little data obtainable from plantations as to quantities of sugar produced per acre with and without fertilization, although it would be unreasonable to suppose the increase does not exceed by a good margin 635 ℔. of sugar per average acre.

The tendency on the plantations during the past year or so has been toward a reduction of phosphoric acid and an increase in potash ; in fact, the average formula is 1 per cent. lower in phosphoric acid and 1 per cent. higher in potash for the crop of 1903 than for that of 1902. With few exceptions, where this change has been made, good results have been obtained.

In the report of the Committee on Fertilization for last year the statement was made that potash could sometimes be used to little advantage in applying large amounts of the element to lands poor in lime. To quote from the last report, 'lime is essential to the most advantageous use of potash, and where the lime of the soil is low it should be augmented previous to the addition of potassic fertilizers.' This point with reference to potash is a very important one, as there is not only danger, where the lime in a field is low, of not getting full returns from potash applied, but also of injuring the cane. This fact is one that is often disregarded in fertilization, and it is doubtless capable of explaining many of the differences of opinion held by plantation managers with reference to the value of high potash fertilizers. When a potash salt, such as the muriate or sulphate, is added to the soil, dissociation takes place to a large extent, and more of the base—potash—is taken up by the cane roots than of the acid part of the salt. This occasions an accumulation of acid in immediate contact with the tender roots of the plants, and if there is no convenient base (such as lime) present to neutralize immediately this acidity, considerable harm may result. Lands standing well in lime can therefore receive a more liberal supply of potash than lands low in lime, the potash in the two soils showing the same degree of deficiency. This holds true for other fertilizing compounds, and will doubtless help to explain why complete fertilizers, containing 200 ℔. of each element in a soluble form, gave a loss of 14 per cent. of sugar, when 100 ℔. of each element gave a gain of 20 per cent. as shown in a previous table. (Ibid., December 1903.)

AVAILABILITY OF ELEMENTS.

Considerable data are at hand to give an adequate idea of the amounts of lime, potash, phosphoric acid, and nitrogen that are present in the soils of the respective islands, the subjoined table representing average results of about 100 analyses :—

Island.	Lime.	Potash.	Phosphoric acid.	Nitrogen.
Ohau	0·380	0·342	0·207	0·176
Kauai	0·418	0·309	0·187	0·227
Maui	0·395	0·357	0·270	0·388
Hawaii... ...	0·185	0·346	0·513	0·540

These results were obtained by the ordinary agricultural method which was in use at the Experiment Station prior to the adoption of aspartic acid as a soil solvent, and although an absolute analysis would give somewhat larger results, these are comparative to a large extent as showing the proportions of lime, potash, phosphoric acid, and nitrogen present in the island soils.

The amounts of the mineral ingredients which are found to be available are as follows:

Island.	Lime. Per cent.	Potash. Per cent.	Phosphoric acid. Per cent.
Oahu	·01568	·00256	·00012
Kauai	·01367	·00249	·00013
Maui	·01764	·00312	·00012
Hawaii	·00789	·00156	·00014

or reducing these percentages to a more tangible form, we have:—

Island.	Lime.	Potash.	Phosphoric acid.
Oahu	549 lb.	89 lb.	4·2 lb.
Kauai	478 ,,	87 ,,	4·5 ,,
Maui	617 ,,	109 ,,	4·2 ,,
Hawaii	276 ,,	54 ,,	4·9 ,,

which quantities represent the amounts of the essential mineral elements in 1 acre of soil, to a depth of 1 foot, that are in a condition to be removed through the several actions of total cropping, during the growth of one crop.

It is interesting to note that Kauai stands highest in lime, Maui in potash, and Hawaii in phosphoric acid. The smallest percentage of lime is on Hawaii, while Kauai is lowest in potash and phosphoric acid.

If, however, we consider the availability of these elements instead of the actual amounts in the soil, a somewhat modified order presents itself: Maui and Oahu are both higher in available lime than Kauai, Oahu standing first. Maui, with the highest total content of potash, has also more of that element in an available form than the other islands. The amounts of available phosphoric acid show little variation, notwithstanding a difference between ·187 per cent. total phosphoric acid on Kauai and ·513 per cent. on Hawaii. This latter ingredient is so closely bound up in iron and aluminic compounds as to be practically insoluble: on Hawaii 9 tons of the element per acre scarcely yield 5 lb. in an assimilable form.

Having considered the method in use for gauging the availability of the mineral elements in question, and having noted the amounts in which they are present in the soils of the respective islands, we will next consider the demands of the crop.

We will compare the amounts of available elements in the soils of the respective islands, with the amounts of these elements that would be required by a crop producing 5 tons of sugar. The nitrogen contents of the lands are not given, as at the present time we have no reliable method for determining its availability:—

Island.	Lime in soil.	Lime required by crop.	Potash in soil.	Potash required by crop.	Phosphoric acid in soil.	Phosphoric acid required by crop.	Nitrogen required by crop.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Oahu	549		89		4·2		
Kauai... ...	478		87		4·5		
Maui	617	164·7	109	509·2	4·2	74	32·9
Hawaii ...	276		54		4·9		

It will be noticed from the above figures that lime is the only one of the elements that would appear to be present in sufficient quantity for the needs of the crop. But when we consider the statement previously made, concerning the small proportion of lime that is taken up by the crop on some upland soils as compared with the proportion removed by the

other factors involved in total cropping, we may see that the average lime content is not so large, but then we must consider it very carefully. Maui stands highest in available lime, having 617 ℔. on an average to the acre, but if only 15 per cent. of that amount could be utilized by the crop, as in the instance above referred to (which was most likely an extreme case), only 92·55 ℔. would go to the crop where 164·7 ℔. were needed. Even if the cane gets on an average 30 per cent. of the lime removed, but small margin would be left on Maui, above actual crop requirements, while on Oahu there would be just enough, and on Kauai and Hawaii a marked deficiency.

The potash is found to be very much too low on all the islands for supplying the wants of the cane, and it is readily seen why it was found necessary, during recent years, to increase the proportion of that element in fertilizers applied.

Concerning phosphoric acid the dearth of this constituent in available quantities in our island soils is very apparent, but we are almost convinced that the aspartic acid method for soil analysis would indicate this ingredient to be lower in availability than it really is. (Ibid., January 1902.)

FERTILIZERS USED ON THE DIFFERENT ISLANDS.

The amount of fertilizer to be added to any land involves a consideration of the available constituents of the soil and the demands of cropping. The form in which its ingredients should exist is influenced by a consideration of their respective properties and the existing climatic conditions of the localities in which they are to be applied.

On the island of Oahu, the average mixed fertilizer contains its phosphoric acid in the water-soluble and citrate-soluble forms: the potash is in the form of sulphate; and the nitrogen is applied in three forms, as nitrate of soda, sulphate of ammonia, and organic material.

On Maui fertilizers are applied to a large extent in the same forms as on Oahu, the water-soluble and the insoluble phosphoric acid being somewhat lower. The three forms of nitrogen are generally used in the same fertilizer, although nitrogen as ammonium sulphate is in excess of the organic and nitric. The total nitrogen is 0·6 per cent. higher than on Oahu.

On Hawaii on account of the diversity of conditions, fertilizers are naturally found to vary more in their composition than on the other islands. In the Hilo district owing to the heavy rains, nitrate of soda cannot be used without liability to waste, and potash in the form of chloride is in disfavour owing to its depleting action on the lime content of the soils which are already low in that constituent. Most of the nitrogen used in the district is derived from organic sources and also in some measure from sulphate of ammonia, although some few fertilizers used during the past year contained nitrate. In Hamakua phosphoric acid is applied mostly in soluble forms, the nitrogen as a rule being derived from ammonium sulphate and the potash from sulphate.

On Kauai nitrate of soda and sulphate of ammonia are favoured as sources of nitrogen for mixed fertilizers, very little of this element being applied in an organic form. According to the analyses of the Experiment Station laboratory, Kauai fertilizers are higher in nitrogen as a rule than those from any other island.

Mr. Geo. Ross, member of the Committee on Fertilization, writes a very interesting letter on the practices followed on Hakalau Plantation. He says: 'At Hakalau I am using almost exclusively a high-grade fertilizer of the following average composition: nitrogen (from sulphate of ammonia and organic ammonia of dissolved bones), 5 to 6 per cent.; phosphoric acid (available), 9 to 10 per cent.; potash in the form of sulphate of potash, 9 to 10 per cent. This is applied to the plant cane at the rate of 900 ℔. per acre in two applications, the first at time of planting and at the rate of 300 ℔. per acre, scattered by hand in the bottom of the furrow, or seed bed, followed by a cultivator to stir it up with the soil. The second application is at the rate of 600 ℔. per acre and just prior to 'hilling up' or when the cane is too high for further cultivation by mule or horse implements. At this time it is scattered, also by hand, on both sides of the cane row and covered up by small ploughs which throw the soil in towards the cane, which is afterwards trimmed up by the hoe.

'The same grade of fertilizer is applied to all ratoon cane, but usually in one application of about 500 ℔. per acre. It is applied to both sides of the row as is done in the case of the second application to plant cane, and is covered over in the same way by small one-horse ploughs. The usual practice is to apply it to the ratoons as early as possible after the first hoeing.

'We have used a fertilizer of this general composition for several years, and although I have experimented to some extent with such special fertilizers as tankage, fish scrap, and bone meal, I have had no results to warrant their continuance. Nitrate of soda, on account of its solubility, is not adapted to this district, where in the past we have been subject to such heavy rainfall whereby this salt is liable to be lost before being taken up by the plant. Lime always gives satisfactory results and this is true of all soils in this district. Filter press cake, when passed through a disintegrator and applied in liberal quantity, gives excellent and lasting results. The same, of course, is true of stable manure. I might state that the percentage of potash in the mixed fertilizer above referred to was increased from 5 to 6 per cent. up to its present strength about three years ago, and with marked results. This was suggested to me from observing the luxuriant growth produced by ashes from timber burnt in forest clearing.'

On some plantations a most commendable system is followed of modifying the composition of fertilizers to suit the requirements of the different fields. Mr. D. C. Lindsay, of Paia plantation, says: 'Our regular plant cane mixture is composed of superphosphate, sulphate of potash, nitrate of

soda, and sulphate of ammonia. We have each field we plant analysed, and vary the proportions of the above ingredients to suit the analysis, so that, as a rule, every field has a different fertilizer to suit its requirements.

'We sometimes use as a special fertilizer a mixture of nitrate of soda and coral lime in equal quantities, and apply about 400 to 500 ℔. per acre. We apply this as late as July and August in the same manner as the plant cane mixture.

'The difference between our plant cane and ratoon mixture, is that in the latter we increase the proportion of nitrate of soda and decrease the phosphoric ingredient.'

Mr. John Watt, of the Committee on Fertilization, in writing concerning the practices followed at Honokaa, says that it is customary to apply from 500 to 800 ℔. of mixed fertilizer per acre for the crop. 'On poor upper lands we give only one. With only one application we distribute the fertilizer in the furrow before the seed is put in, mixing with the soil by a subsoiler or small plough. Where we give two applications, the first is given as above and the second is given when the cane has about two months' growth, sometimes a little later, depending upon the condition of the cane, by distributing the fertilizer along side of the stool and either hoeing it in or running a cultivator along the furrows.'

This year the general composition of mixed fertilizer applied to Honokaa has been as follows :—

9-10 per cent.	Phosphoric acid.
8 ,, ,,	Ammonia from sulphate.
5 ,, ,,	Potash from sulphate.

Mr. Watt says: 'The above is the fertilizer which we have used this year, and the weather has been so that we cannot tell what results we may have from it. Last year we used a different mixture on the upper lands with very good results, the analysis of which was as follows :—

15 per cent.	Potash from sulphate.
5 ,, ,,	Ammonia from sulphate.
10-12 ,, ,,	Phosphoric acid.

'With the above fertilizer the cane came up very well and maintained a vigorous growth until it was checked by the very dry weather during the past five months. When we planted this cane we gave it an application of 700 ℔. of the above fertilizer with the seed and about four months later we gave it 700 ℔. per acre more.'

For some years past Mr. Watt has been very careful in regard to the preserving of all stable manure, which is liberally treated with a dressing of superphosphate to prevent loss of ammonia. Both with this compound and with mud-press cakes which have been passed through a disintegrator he has obtained splendid results. (Ibid., February 1902.)

IRRIGATION.

ANCIENT WATER RIGHTS.

The population of Hawaii was very dense in prehistoric times, as the remains of old houses and fields bear convincing testimony. Nearly all the streams were led out by ditches called 'Auwais,' and the water was used for growing taro, the national food, and other vegetables. The ditches were excavated in surface earth and maintained by joint users, each of whom had to devote so many days each month toward repair. The water was also distributed between its users by set rules and at stated times; each district with its branch ditch getting so many hours flow of the stream. The land thus cultivated was always in the vicinity of the stream, as no long ancient conduits were built, and was styled 'taro' land in contrast to 'kula,' or dry land, which carried no water rights. The native Hawaiians have protected with the greatest zeal their water rights through taro land, which the gradual growth and expansion of sugar plantation interests have tended to absorb.

MODERN IRRIGATION.

The present water supply of the islands is derived from two sources:—

(1) By pumping ground or artesian waters from wells and pumps, excavated near the sea-shore. The pumps are driven with either coal or oil as fuel, or by electricity generated from water power.

(2) By gravity, from the natural flowing streams, the impounding of flood waters of same, and by the interception of ground water by tunnelling.

DUTY OF WATER.

One million gallons of water per day is the quantity found necessary to irrigate each 100 acres. Sugar-cane is grown in furrows, about 5 feet apart, into which the water is turned from the field ditches. When the seed is newly planted, the water is turned on every three or four days, but after that an application of once each ten days is considered sufficient. The above quantity, if applied uniformly to the whole surface, would make a depth of 134 inches in one year excluding rainfall and evaporation which is possibly 50 inches, yearly, in most of the irrigated properties. It means the application, for a crop period of one year and a half, of 22,800 tons of water per acre to produce 50 to 80 tons of cane, which would appear to be excessive.

It is safe to presume that leaky reservoirs, ditches, and unequal and wasteful distribution prevent the application of not more than one-third of the above quantity of water to the roots of the cane where its value would be utilized.

Economies of various kinds in the application of water are now being gradually introduced, which will enable the best results to be obtained. Nearly all the water so far developed has been used by the owners on their own property. Lately

surplus has been disposed of to adjacent owners at a flat rate of from $8·00 to $10·00 per million gallons. Great credit must be given the American pioneers who have developed such splendid supplies under so many adverse conditions in the past twenty years in those remote islands in the Pacific. By no other people, except perhaps the Mormon settlers of Utah, has so much enterprise been displayed and so many sacrifices been made in developing the non-productive country into one of pronounced prosperity. (*Louisiana Planter*, October 29, 1904.)

YIELD.

'*Sugar in the Hawaiian Islands.*—The sugar lands of the Hawaiian Islands offer one of the best investments in the whole world. Of course planters have trouble, but with sufficient rains and without irrigation the average yield is 3 tons of sugar to the acre. With irrigation it is 8 to 12 tons, 10 tons being the average, and as 10 tons of sugar at $3·62½ per 100 ℔. will bring $72·50 per ton, or $725 per acre, it will be easily seen that there is hardly any obstacle that cannot be overcome.'—*The Investor.*

The foregoing is but a fair sample of the many misleading statements concerning the sugar industry of Hawaii which appear from time to time in various papers and journals.

Were the facts therein stated true, there would indeed be hardly any obstacle in our sugar industry, which could not be overcome—even to the paying of dividends, which have been the more noticeable these past two years by reason of their absence.

It is probably a waste of time to refute such statements as they undoubtedly will continue to appear, but it is well perhaps to put ourselves on record.

Many of our plantations have, under favourable conditions —a good price for sugar, low price for labour and plenty of it— paid very well, but with the low price of sugar resulting from a greatly increased production of beet and cane sugar in the sugar-producing countries, the margin of profits has become very small.

Sugar can be produced at a profit in Hawaii only when cultivated and manufactured on a large scale, and the difficulties in establishing and carrying on a large plantation are very great.

More than two-thirds of the cane grown in the islands is produced by artificial irrigation, and water for this purpose, in quantities sufficient to justify engaging in cane culture, can only be obtained from surface streams or by pumping from subterranean sources.

Owing to the nature of the formation of the islands and of the rains, the exposed portions have been worn into deep gorges or gulches with high ridges between them; these gulches in many instances are from hundreds to thousands of feet in depth with precipitous sides, and follow each other in close succession, with but small areas of land between suitable for cultivation.

For the most part the arable land is far removed from the sources of water supply, and to convey the water from the gulches in the rainy belt to the arid arable sections requires ditches of many miles in length and also flumes and pipe lines to cross intervening gulches. Dams and reservoirs to impound the water are also constructed.

In obtaining water by pumping from below the surface powerful machinery of large capacity is required.

To procure an adequate supply of water the expense involved in the first instance ranges from $100,000 to $500,000, and heavy and continuous expense is incurred in maintaining the extensive water systems. The machinery, buildings, and appliances necessary to manufacture sugar on a scale to justify the undertaking, costs from $100,000 to $500,000 and upwards, exclusive of the cost of the land.

Undoubtedly our soil is productive, and the yield is comparatively large on most of the plantations, but it is manifestly unfair to pick out one plantation where the yield averages 10 tons of sugar per acre, and take that as the standard.

The average yield of all plantations since 1895 has been as follows :—

SUGAR YIELDS OF THE HAWAIIAN ISLANDS.

Year.	Acres.	Tons of Sugar.	Yield per acre.	
			Pounds.	Short tons.
1895	47,399½	153,419½	6,472	3·24
1896	55,729	227,093	8,148	4·07
1897	53,825½	251,126	9,331	4·67
1898	55,235½	229,414	8,306	4·15
1899	60,308	282,807	9,378	4·69
1900	66,773	289,544	8,672	4·34
1901	78,618½	359,133	9,136	4·57

Furthermore, it must be borne in mind that from eighteen to twenty-four months elapse from the time the land is broken for planting until the harvesting is concluded. Planting is generally done in the summer months, and grinding is begun about November of the following year, and finished about the following June. Thus the crops overlap. Moreover, the fields cannot be continuously cropped, but must be allowed to lie fallow from time to time, and about three times the area of land is needed to maintain continuous yields than is required to produce an annual crop.

The cost of labour is high—our labour troubles and experiences have been so often thrashed out and conclusions arrived at by those who thought they understood our situation, that we will not enter into a discussion of the matter. Suffice to say, that so far as Europeans (except Portuguese) and Americans are concerned, it has been found that they were

unfitted for field work and will not and cannot perform such labour.

The average cost of production of sugar on sixteen representative plantations (joint stock companies issuing and printing annual reports) for the crop of 1901-2 is found to be \$49·00 per ton of sugar at the mill; marketing expenses are from \$11·50 to \$15·00 per ton, according to location. This average does not take into account any expenses for permanent improvements, but is derived solely from the operating expenses.

Of the sixteen plantations we find that for the year ending December 31, 1902:—

Nine paid no dividends, some running behind.

Three paid 6 per cent. dividend.

One paid 5 per cent. dividend.

Two paid $4\frac{1}{2}$ per cent. dividend.

One paid 1 per cent. dividend.

The previous year's drought on portions of Hawaii and Maui affected the earning capacity of many plantations, but we have eliminated most of those so affected.

We trust that the foregoing may tend to show that producing sugar in these islands, at a profit, is not such a 'cinch' as some may believe. (*Hawaiian Planters' Monthly*, May 1903.)

The Productiveness of Hawaii.

The U. S. *Census Bulletin* of May 19 reviews agriculture in Hawaii and incidentally gives some interesting data concerning the sugar industry there. In the whole territory there were 65,687 acres of land planted in sugar-cane in 1899 and from this land there were produced 2,239,376 tons of sugar-cane or a shade over 34 tons per acre. The land in sugar-cane is three-fourths of the area of cultivated land and the sugar-cane produced reaches in value four-fifths of all crops.

Sugar and molasses were made by the operators of forty-two plantations, thirty of whom consumed only their own cane, while twelve bought outside cane also. Four large sugar houses in process of construction have since increased these establishments to forty-six. Two of the sugar houses raised no cane for their own account.

The cane from 138 farms was sold to the sugar houses, producing an average of 1,250 tons of cane per farm, while the forty-six plantations with sugar houses produced an average of 44,431 tons, short tons, of sugar-cane each.

The element of fertilization stands out prominently. To produce 2,239,376 tons of sugar-cane there were expended for fertilizers \$1,326,407—or about 60c. per ton of cane produced—and on the average of 34 tons production per acre, Hawaii fertilizes her cane lands at a cost of about \$20·00 per acre. We believe that such intense cane culture as this has never been attempted in Louisiana. The cost of raising sugar-

cane and delivering it to the factory is placed at $4·30 per ton. *(Louisiana Planter.)*

EXPENSES.

But the planters on the windward side get their water directly from the clouds in the form of rain. They slightly ridge there, but nothing like the ridge we have here—it is a mere ridge hardly more than 2, 3, and 4 inches high. They cultivate with cultivators after the order, perhaps, of the most advanced planters of this state. The yields on the rainy side are very small compared with those on the leeward side—a clear demonstration to me when I was there that irrigation with proper soils and plenty of fertilizers in a tropical climate constitute perhaps conditions under which cane can be grown more largely, and bountifully, and cheaply than in any other place in the world.

Now that you have called upon me, Mr. President, I don't suppose it would be out of order to read before this association a letter that I received yesterday reciting the expenses of one of the large plantations on the island, and which they promised me when I was over there. I received it yesterday. This will give you an idea of their expenses. This is from the celebrated Ewa plantation, on the island of Oahu. The 'clearings,' which I will have to explain, is the trash from the growth of last year's cane laid on the earth—laid between the rows of cane, where it is allowed to remain until the cane is harvested. As soon as the cane is harvested, they send men through the field, who take this trash, pull it out and burn like we do here. Clearing, $5·51 per acre; steam plough and mule ploughing, $14·50 per acre; for ditching for irrigation, $2·05; for cutting and hauling seed (they plant only tops) $8·22; preparing and planting, $9·04; for fertilizers, $41·13 per acre. That is commercial fertilizer.

Dr. Maxwell, who used to be with me, was formerly the Director of the Station. He was in charge of what is called the Sugar Experiment Station over there. One of his duties was to visit each plantation several times during the year, examine the soils, and give his directions and advice; hence Dr. Maxwell has the fertilizer prepared to suit the soil of the different plantations. On the windward side we need a very different fertilizer than on the leeward side. The windward side has been washed continually by heavy rainfall and is therefore comparatively poor. On the leeward side there is less rainfall. There are different fertilizers, therefore, which are prescribed for the different plantations on the island. In this instance the cost was $41·00 per acre, for watering $37·13, for pumping $35·62, or say a total of $63·00 for irrigating an acre. I shall have to make another explanation here. They contract with a head Chinaman to irrigate 100 acres of land from the time of planting until harvest, at so much per ton for the cane made thereon. That is what is charged as 'watering.' Then the plantation runs eight large pumping plants, of enormous pumping capacity; they cost $1,750,000 and they are run all the time. The cost of running is $35·00 per acre. The cost of Chinese labour $37·13—making a total of

\$63·00 per acre for irrigation. The stripping of cane, \$15·25. The place is rented on a lease from a Scotchman named Campbell, and for which they paid \$54·63 per acre. I shall have to explain that a little; he gets such a per cent. of the sugar made; and, as you will see, the percentage of sugar was enormous and therefore his rent was large. For manufacturing per acre, \$27·15; for bags, \$9·77; or a total of \$292·74 expense per acre. Now, that sounds large; but you will find in a very short while from the yield that the cost is comparatively small and the profits large. 'We planted,' he says, 'from August 10 to November 27 in 1897. We harvested that crop from February 1 to August 25, 1899.' He could not give me the figures this year because they were still grinding.

The yield was 117,835 tons of cane; per acre, it was 79 tons. The purity of juice was 87 per cent. It took 7·71 tons of cane to make a ton of sugar. They made 15,289½ tons of sugar; or an average of 10¼ tons per acre of sugar. They sold the sugar at \$84·50 per ton in Honolulu, which it cost them \$28·00 to make—\$28·59, it is figured here per ton of sugar, and they sold it for \$84·50. These figures will be a little instructive to the planters here. I want to say further that the owners, or rather the general agents, told me that when they began planting ten or fifteen years ago, the yield was 1 to 2 tons to the acre; when they ploughed 12 to 15 inches, they gradually got down deeper until they went 3 feet, expending \$40·00 per acre for fertilizers, and then the plantation paid. Now, Mr. Renton in writing me on October 8, sending me the figures I have just given, concludes his letter by saying that wages have materially increased on the islands, and that by reason of this increase he believes it would be safe to add 25 per cent. to the figures in estimating the cost of taking off the present crop. (Dr. Stubbs: *Hawaiian Planters' Monthly*, December 1900.)

EXPERIMENTS WITH SWEET POTATOS IN JAMAICA.

In this volume of the *West Indian Bulletin* (pp. 41-52) there were published the results of a series of experiments carried on at Barbados with the view of ascertaining the best sweet potatos cultivated in the island.

A similar series of experiments has been carried out in Jamaica, and the following report by Mr. H. H. Cousins, M.A., F.C.S., is reproduced from the *Bulletin of the Department of Agriculture*, Jamaica, for purposes of comparison, as most of the varieties were tried in both series of experiments:—

The value of the sweet potato has been brought home to the people of Jamaica by the great benefits it conferred on the community, after the destruction wrought by the hurricane of 1903, as a quick-growing crop of high nutritive qualities for providing a speedy supply of food. The Agricultural Society distributed a large quantity of slips received from Barbados and the Prison Farm at Spanish Town. It is believed that the large crops of sweet potato grown all over the island did a great deal to alleviate the position of the peasantry during the past year.

The sweet potato has been the subject of special experiments by the Imperial Department of Agriculture for the West Indies, and Mr. Hart, of Trinidad, has already issued seedling varieties of great promise. To test the comparative merits of the sweet potatos available in Jamaica, sixteen varieties were grown at the Hope Experiment Station in plots each of $\frac{1}{40}$ acre. At the end of seven months' growth (February to October) the tubers were lifted, weighed, sampled for analysis, and submitted to a test as to cooking qualities. No irrigation was employed. The rainfall during the period of growth was as follows :—

1904	Inches.
March	7·51
April	4·11
May	1·63
June	9·67
July	1·28
August	1·76
September	5·21
Total	31·17

It is suggested that under irrigation some of the varieties, such as Thompson's Favourite, for instance, would have yielded much more favourable results.

The general experience seems to be that the sweet potato is rather an erratic crop upon which to carry out field experiments, and the yield of tubers in this series cannot be regarded as in any way a final estimate of the comparative merits of the sixteen varieties.

The results, as recorded by Mr. Cunningham, of the Experiment Station, together with his personal estimate of the eating quality of each variety, are as follows :—

Name of Variety.	Shape of Leaf.	Colour of Stem.	Colour of Tubers.	Size of Tubers.	Flavour when cooked.	Yield in pounds per acre.	Rem : ks on growth.
Fire Brass	Cordate	Green	Pale-red	Very large	Good	24,640	Vigorous
Moffard	,,	,,	Red	Large	Excellent	21,480	Medium
White Gilkes (6 mos.)	5-lobed	,,	White	Large	Good	22,000	,,
Trinidadian No. 1 ...	Cordate	Purple	Red	Medium	Very good	24,640	,,
Vincentonian	5-lobed	Green	Red	Medium	Good	19,440	,,
White Sealy	Cordate	,,	White	Very large	Good	13,841	Vigorous
Trinidadian No. 2 ...	,,	,,	Pale-red	Very large	Very good	25,488	,,
Brass Cannon	,,	Purplish-green	Red	Very large	Good	18,288	Medium
Caroline Lee	3-lobed	Green	Yellowish-white	Large	Excellent	13,000	,,
Red Sealy	Cordate	,,	Red	Medium	Very good	18,400	,,
White Gilkes (3 mos.)	5-lobed	Yellowish-green	Yellowish-white	Medium	Excellent	15,841	Vigorous
Thompson's Favourite	Cordate	Purple	White	Medium	Very good	14,880	,,
Tailor's Scissors ...	5-lobed	,,	Red	Medium	Good	5,760	,,
Roosevelt	3-lobed	Yellowish-green	White	Medium	Good	3,280	Very vigorous
Minuet	Cordate	Green	Yellowish-white	Large	Very good	23,400	Medium
Governor	5-lobed	Purple	Red	Medium	Excellent	7,120	Vigorous

'Trinidadian No. 2' gave the largest yield, viz., 11 tons 7½ cwt. This variety gives very large, cordate tubers of good quality. 'Trinidadian No. 1' and 'Fire Brass' come second with a yield of 11 tons.

I am inclined to place 'Trinidadian No. 1' in the highest position and to class it as the best variety in this series on account of the high quality of the tubers both in total solids and in starch and sugars. Our results with this new Trinidad seedling are such as to warrant its general trial by the people all over the island.

CHEMICAL ANALYSES.

Samples of all the varieties were sent to the Laboratory and records taken of the average weight of a tuber, its general appearance, and of the flavour when cooked. The latter was decided upon by a small committee consisting of a chemist and three experienced black ladies. On the whole, their verdict is in substantial agreement with the opinions of Mr. Cunningham which were arrived at quite independently and based upon different samples of the tubers.

The variety with the highest percentage of total solids is 'Governor' with the very high content of 39·8 per cent. 'Trinidadian No. 2' gave the lowest result with 30·58. Even this is far above the average American sweet potato which contains only 29 per cent. of total solids.

The variety 'White Sealy' heads the list in starch content with 30·94, a truly extraordinary amount. The lowest starch content is that of 'Fire brass' with 23·74 per cent.

The sugars vary from 2·94 per cent. in 'Thompson's Favourite' to only 0·232 per cent. in 'Fire Brass.'

The fibre shows little variation (·567 to ·828).

The nitrogen content varies from 0·7 in Thompson's Favourite' (=4·7 per cent. of protein) to 0·16 in 'Trinidadian No. 2' (=1 per cent. protein).

A determination of amides in the variety 'Tailor's Scissors' indicated that rather over one-fifth (22·2 per cent.) of the total nitrogen exists as amides.

The results shown by the analyses of this series of varieties indicate that the sweet potato as grown in Jamaica is a food of very high quality. The bulk of the solid matter consists of starch. The standard of solids and of starch shown by this collection of varieties is far in excess of that obtaining with sweet potatos grown in the United States, and places the tropical product in a very favourable position by comparison.

With regard to the 'sweetness' of the sweet potato, the indicated proportion of sugars is not enough to account for the sweet taste of the tubers when cooked and eaten. To test whether the process of cooking increased the sugar content, an experiment with the variety 'Trinidadian No. 1' was carried out:—

	Per cent.				
	Moisture.	Total Solids.	Starch.	Glucose.	Total Sugars.
Uncooked ...	69·45	30·55	25·3	0·099	1·6
Cooked ...	69·99	30·01	21·63*	4·31*	7·69*

This result is very striking. *The process of cooking the sweet potato has increased the glucose from 0·1 per cent. to 4·3 and the total sugars from 1·6 to 7·69 per cent.*

Experiments are now being undertaken to ascertain the exact chemical nature of this change. I believe that this fact has not hitherto been recorded, and that it explains why a sweet potato should taste so sweet when eaten despite the moderate amount of actual sugars in the raw tuber.

Experiments were also undertaken to indicate the change in the tubers on keeping. Tubers of the variety 'White Sealy' were analysed when freshly dug and after keeping for five weeks in the open air.

The results were as follows :—

	Per cent.			
	Moisture.	Total Solids.	Glucose.	Total Sugars.
Fresh tubers	67·19	32·81	0·244	1·1
Old tubers	69·45	30·55	0·434	4·0

This indicates that the tubers tend to a development of sugars at the expense of other constituents on keeping.

These preliminary results suggest various lines of inquiry which we hope to follow up as opportunities occur.

*Calculated on same content of total solids as uncooked.

ANALYSES OF SWEET POTATOS.

Name.	Average weight in ounces.	Per cent.						
		Total Solids.	Moisture.	Starch.	Glucose.	Total Sugars.	Fibre.	Total Nitrogen.
Fire Brass	15¼	32·79	67·21	23·74	...	0·232	0·579	0·49
White Gilkes (6 months) ...	20½	35·81	64·19	24·96	...	0·339	0·638	0·25
Moffard...	20¾	33·48	66·52	23·84	0·38	2·2	0·698	0·42
Vicentonian	25¾	33·53	66·47	29·40	0·24	0·95	0·667	0·28
White Sealy	26	32·81	67·19	30·94	0·24	1·1	0·653	0·21
Trinidad No. 1	19	33·87	66·13	28·26	0·21	2·2	0·665	0·28
Brass Cannon	50	32·99	67·01	25·81	0·38	2·5	0·663	0·22
Caroline Lee	9¾	37·03	62·97	28·41	0·77	2·5	0·655	0·25
Trinidadian No. 2	20¼	30·58	69·42	22·43	0·5	2·85	0·637	0·16
Tailor's Scissors	16¾	36·69	63·31	29·12	0·5	2·17	0·723	0·45*
White Gilkes (3 months) ...	12¼	39·32	60·68	29·37	0·36	2·86	0·699	0·35
Governor	21	39·82	60·18	28·69	0·42	2·2	0·692	0·39
Roosevelt	7	33·72	66·28	25·14	0·5	2·86	0·828	0·39
Red Sealy	12¾	33·24	66·76	28·19	0·66	2·75	0·567	...
Minuet	9¼	32·23	67·77	27·83	0·37	2·7	0·604	0·35
Thompson's Favourite ...	15	33·29	66·71	28·12	0·35	2·94	0·557	0·7

*Albuminoid N. = 0·35 per cent. *Amide N. = 0·10 per cent.

MANURIAL VALUE OF WEEDS IN CACAO AND LIME ORCHARDS.

The following short note relative to the treatment of orchard soils has been forwarded by the Hon. Francis Watts, C.M.G., D.Sc., F.I.C., F.C.S. It contains information that is likely to be useful for reference, and is to be taken as supplementing the paper read by Dr. Watts at the West Indian Agricultural Conference of 1901 (and published in the *West Indian Bulletin*, Vol. II, pp. 96-8) on the 'Treatment of Soils in Orchard Cultivation in the Tropics.' In that paper it was suggested that the best kind of treatment to adopt was to leave the soil untilled, the only cultivation being the periodical cutting back of the rank grass and weeds with the cutlass:

In order to ascertain the manurial value of weeds growing in young orchards, e.g. of cacao, limes, etc, an experiment was undertaken jointly by Mr. J. Sowray, of Dominica, and the Imperial Department of Agriculture.

A portion of a young cacao orchard having a normal growth of weeds was selected and the weeds were cleared over an area of 15 x 15 feet. These were found to weigh, when fresh, 74½ lb., this being at the rate of 128·75 cwt. per acre. After drying, the weight was 49½ lb. or 85·5 cwt. per acre, the loss on drying being 33·55 per cent.

The air-dry material was found on analysis to contain:—

Moisture	10·83 per cent.
Nitrogen	·74 " "
Phosphoric acid (P_2O_5)	·22 " "
Potash (K_2O)	·99 " "
Total ash	10·33 " "

From these figures it follows that upon these weeds being returned to the soil as manure, the soil will receive—

Nitrogen, 70·8 lb. per acre; equal to sulphate of ammonia, 334 lb.

Phosphoric acid, 21·1 lb. per acre; equal to *tricalcium phosphate, 46 lb.

Potash, 94·8 lb. per acre; equal to sulphate of potash, 171 lb.

This, taken in connexion with the very considerable amount of vegetable organic matter, constitutes a substantial manuring.

This material may be regarded in the light of circulating capital, being used as manure, then reappearing partly as crop, (cacao or limes) and partly as a new growth of weeds; at the same time the condition of the soil is being steadily improved by the circulation.

One effect of the use of manures in orchards will be to increase the quantity of weeds, rendering more care and attention necessary on the part of the cultivator, but there will be a steady increase of vegetable matter in the soil, and

*Equal to *about* 1 cwt. of basic phosphate.

consequently improved condition and improved fertility ; nor is it too much to say that under some circumstances it may be well to apply manures for the sake of the additional growth they will produce for use as a green dressing.

Weeds during their growth will doubtless lock up and retain much plant food, this however will be steadily and periodically returned to the soil by the periodic cutting down of the weed crop. In some cases it may be desirable to supplement the natural growth of weeds by the cultivation of some crop for green dressing. For this purpose woolly pyrol (*Phaseolus Mungo*) appears to be one of the most useful plants.

In orchard work it is essential to prevent the formation of anything like a turf, but little care is required to prevent this. From time to time the grass and weeds should be cut down, and perhaps be lightly covered with soil : if there is danger of a turf forming the soil should be forked. A proper appreciation of the use and value of weeds and green dressing will do much to improve the conditions of orchard cultivation in the tropics.

AGRICULTURAL CONFERENCE, 1905.

The fifth West Indian Agricultural Conference was opened on Wednesday, January 4, in the Council Chamber, Princes' Buildings, Port-of-Spain, Trinidad, under the presidency of Sir DANIEL MORRIS, K.C.M.G., Imperial Commissioner of Agriculture for the West Indies. All of the representatives were present with the exception of those from St. Vincent, Grenada, and Tobago, who arrived the following day. His Excellency the Governor of Trinidad (Sir HENRY M. JACKSON, K.C.M.G.), His Grace the ARCHBISHOP, the Colonial Secretary (the Hon. HUGH CLIFFORD, C.M.G.), and a large number of prominent members of the official, commercial, and agricultural communities also attended the opening ceremony.

The following is the list of Representatives from the several West Indian Colonies who attended the Conference :—

JAMAICA.

The Director of Public Gardens and Plantations (The Honourable WILLIAM FAWCETT, B.Sc., F.L.S.)

The Representative of the Agricultural Society (J. R. WILLIAMS, Esq., M.A.)

BRITISH GUIANA.

Representative of the Board of Agriculture (The Honourable B. HOWELL JONES.)

The Superintendent of the Botanic Gardens (A. W. BARTLETT, Esq., B.A., B.Sc., F.L.S.)

The Lecturer in Agriculture (E. W. F. ENGLISH, Esq., B.A.)

The Assistant-Instructor in Agriculture (J. E. BECKETT, Esq.)

TRINIDAD AND TOBAGO.

Representatives of the Trinidad Agricultural Society :—
PETER ABEL, Esq., (Usine, St. Madeleine.)
J. G. DEGANNES, Esq.
EDGAR TRIPP, Esq., Secretary.
The Government Analyst and Professor of Chemistry (Professor P. CARMODY, F.I.C., F.C.S.)
The Superintendent of the Royal Botanic Gardens (J. H. HART, Esq., F.L.S.)
The Principal of Queen's Royal College (W. BURSLEM, Esq., M.A.)
The Principal of the College of the Immaculate Conception (The Revd. FATHER NEVILLE.)
The Inspector of Schools (J. H. COLLENS, Esq.)

Additional Representatives for Trinidad :—
The Honourable G. TOWNSEND FENWICK, C.M.G.
The Honourable S. HENDERSON.
The Rev. Dr. MORTON.

Representative for Tobago :—
The Curator of the Botanic Station (HENRY MILLEN, Esq.)

WINDWARD ISLANDS.

Representative of the Grenada Agricultural Society (E. M. DEFREITAS, Esq.)
The Inspector of Schools, Grenada (J. A. HARBIN, Esq.)
Representative of the St. Vincent Cotton Growers' Association (EDWIN RICHARDS, Esq.)
The Agricultural Superintendent, St. Vincent (W. N. SANDS, Esq.)
The Agricultural Instructor, St. Lucia (GEORGE S. HUDSON, Esq.)

BARBADOS.

Representatives of the Barbados Agricultural Society (The Honourable FORSTER M. ALLEYNE (Vice-President) and G. SEBERT EVELYN, Esq.)
The Island Professor of Chemistry, in chemical charge of Sugar-cane Experiments (Professor J. P. D'ALBUQUERQUE, M.A., F.I.C., F.C.S.)
The Agricultural Superintendent of Sugar-cane Experiments (J. R. BOVELL, Esq., F.L.S., F.C.S.)
The Head Master of Harrison College (HORACE DEIGHTON, Esq., M.A., F.R.A.S.)

LEEWARD ISLANDS.

The Government Analytical Chemist and Superintendent of Agriculture (The Honourable FRANCIS WATTS, C.M.G., D.SC., F.I.C., F.C.S.)
Dr. H. A. ALFORD NICHOLLS, C.M.G., M.D., F.L.S., etc., Author of 'Tropical Agriculture,' Dominica.
The Officer-in-charge of the Agricultural School, Dominica (ARCHIBALD BROOKS, Esq.)
The Agricultural Superintendent, St. Kitt's-Nevis (F. R. SHEPHERD, Esq.)

OFFICERS

OF THE IMPERIAL DEPARTMENT OF AGRICULTURE FOR THE WEST INDIES.

Imperial Commissioner of Agriculture for the West Indies (Sir DANIEL MORRIS, K.C.M.G., M.A., D.C.L., D.Sc., F.L.S.)
Scientific Assistant (W. R. BUTTENSHAW, Esq., M.A., B.Sc.)
Mycologist and Agricultural Lecturer (L. LEWTON-BRAIN, Esq., B.A., F.L.S.)
Entomologist (HENRY A. BALLOU, Esq., B.Sc.)
Travelling Inspector in connexion with Cotton Investigations (THOMAS THORNTON, Esq., A.R.C.S.)

HONORARY MEMBERS.

The Director of Agriculture for the Dutch West Indian Colonies (C. J. VAN HALL, Esq., Ph.D.) and WALTER POWELL JEFFREYS, Esq., Llandovery, South Wales.

Honorary Secretaries to the Conference { W. R. BUTTENSHAW, Esq., M.A., B.Sc., and ALLEYNE GRAHAM HOWELL, Esq.

The Agricultural Society of Trinidad appointed a Reception Committee in connexion with this Conference as follows :—

The Hon. G. TOWNSEND FENWICK, C.M.G., (Vice-President); the Hon. HUGH CLIFFORD, C.M.G. (Colonial Secretary); the Hon. W. C. L. DYETT, the Hon. SAMUEL HENDERSON; Rev. Dr. MORTON; J. G. DE GANNES, Esq.; PETER ABEL, Esq. (Usine St. Madeleine); RUDOLPH RUST, Esq., and EDGAR TRIPP, Esq. (Secretary). The Committee very kindly made arrangements for the excursions to the Usine St. Madeleine, the Pitch Lake, and to Horqueta and Sangre Grande, on January 7, 10 and 12.

Among those present at the opening ceremony were :— His Excellency the GOVERNOR, accompanied by LADY JACKSON and Lieutenant SAREL, A. D. C., LADY MORRIS, his Grace ARCHBISHOP FLOOD, the Hons. HUGH CLIFFORD, C.M.G., R. G. BUSHE, R. A. WARNER, W. C. L. DYETT, EDGAR AGOSTINI, A. P. MARRYAT, R. H. MCCARTHY, DENIS SLYNE, WALSH WRIGHTSON, C.M.G., EUGENE CIPRIANI, and GEORGE GOODWILLE, Ven. ARCHDEACON SMITH, and a representative gathering of planters and members of the civil service and the commercial community.

The Representatives were received in the Conference Hall at 12 (noon) by his Excellency the GOVERNOR, who opened the proceedings with the following speech :—

On behalf of the colony, and on my own behalf, I beg to extend to the members of the Conference a very hearty welcome indeed to this beautiful and fertile island, which has so well earned the title of the 'Pearl of the Lesser Antilles.' I know it has for a very long time past been Sir Daniel Morris' desire to hold a meeting of the Conference here to enable you to see for yourselves the resources of the island and the means

which have been used to develop them—means which I am happy to say have been blessed with an abundant measure of success. I do not think it is possible to attach too high an importance to the meetings of this Conference, and its institution is one of not the least of the benefits which we owe to the Department which is so ably presided over by Sir Daniel Morris. (Applause.) It enables the practical and scientific agriculturists to come into closer touch and sympathy and exchange their views, and it enables us outside the Conference to benefit by the expression of those views. I am very glad to welcome you to-day. I can also welcome you to a new departure in the Conference, and that is, that you will be able to give a longer time to the consideration of the very important questions with which the papers deal, instead of having to crowd them into two half-days. We shall be very glad indeed to show you all that you think worth seeing in Trinidad, and you will find us not less ready to listen to any comment or advice which your very wide experience may enable you to offer. We want to learn from you as well as enable you to observe what we are doing. I learn from the records of the earlier Conferences that at first they were intended to afford the officers who were engaged in assisting agriculturists throughout the West Indies an opportunity of meeting to exchange their views, and I think great wisdom has been shown in appointing delegates and getting together so large a number of the representatives of agriculture, both practical and scientific, throughout the West Indies. Your united opinions can command attention which it would be impossible for any single colony to expect, and should you find it within the scope of your duties to suggest the removal of any disabilities which may exist in the development of agriculture or the provision of better systems, you may be sure that the expression of your views will command the greatest attention, not only here but also with our masters in Downing Street. (Applause.) Before I sit down—I feel I am rather taking your time up too much, but perhaps the increased length of your Conference will enable you to excuse me—I would like to say just one word, not to the Conference, but to the gentlemen who are attending the meeting. It is this. It has seemed to me that some slight misunderstanding has existed in Trinidad as to the real position of the Imperial Department of Agriculture. I have noticed it stated on more than one occasion that this colony can hardly be said to derive full benefit from that very valuable Department. I think whoever made this comment cannot possibly be aware of, or have given any thought to, the reasons for which the Department was started. You will all remember the visit of the Royal Commission to the West Indies, which, unfortunately, they found almost on the verge of bankruptcy with the very happy exception, I am glad to say, of Trinidad. (Cheers.) Trinidad was able then, as now, to fight its own battle, and therefore, it was felt that there was no excuse necessary for not offering it so much pecuniary assistance as was given to the poorer colonies. That assistance has not been wanting, since we have a grant-in-aid which enables us in a large measure to support our Botanic Station in Tobago. But we do derive good

advantage from the Imperial Department of Agriculture. It is always ready to give us the fullest advice and assistance whenever applied to; and not only that, it looks after us in a way which is not fully understood or appreciated. I have been reading lately how that when disease appears amongst any product which is grown in the West Indies or in any other part of the world, the Department at once sets to work to find out the nature of the disease and the best means of fighting it, so that it is ready to meet any particular misfortune in the way of disease which should visit the West Indies; and that is the great advantage in having the Department. Therefore, I think we benefit in a very large measure, and I am glad to have the opportunity of expressing the thanks of this colony to the head of the Department for his able assistance. (Cheers.) Now, gentlemen, I am not going to detain you any longer. I declare this Conference open, and call upon the President to give you his address. (Applause.)

I. THE PRESIDENT'S ADDRESS.

Sir Daniel Morris then rose and said:

I have pleasure in presiding at the fifth West Indian Agricultural Conference. I congratulate you on being able to meet in so important and progressive a colony as Trinidad for the consideration and discussion of problems which lie at the foundation of the material prosperity of these colonies.

It is my pleasing duty to express to the Government of Trinidad my deep appreciation of the assistance it has rendered in lending this Hall as a meeting place for the Conference and the hearty welcome that has been extended in behalf of the colony by his Excellency the Governor. Our thanks are also due to the Members of the Trinidad Agricultural Society for the arrangements they have made for visits to sugar and cacao estates and for enabling us to become more fully acquainted with the resources of this fertile and beautiful island.

Trinidad is possessed of special features as a meeting-place for those interested in agricultural matters, and there is no doubt that we shall, directly and indirectly, obtain valuable information likely to be of benefit in advancing the agricultural interests in which we are severally concerned.

As you are aware, there has been an interregnum of two years in holding these Conferences, caused by quarantine restrictions. It is hoped that difficulties of this kind will disappear as a result of the more scientific and, it is believed, equally effective measures now in course of being adopted.

The business to be brought before this Conference is fully set forth in the Programme of Proceedings already in your hands. You will observe that there is a long list of subjects proposed to be dealt with, but, as on former occasions, chief attention will be devoted to those of immediate interest and such as have a direct bearing on the improvement and development of the staple industries of these colonies. A prominent position is given to questions affecting the sugar

industry, and a review of the results obtained in recent years in raising varieties of canes yielding more sugar and less liable to disease will show that we have made an appreciable advance in both directions.

The prospects of the sugar industry are more favourable than they have been for many years, and it is realized that the West Indies, after the strenuous efforts made in their behalf, have, at last, obtained a position which should enable them to compete, in the British market, on equal terms with all sugar-producing countries.

As Trinidad is the largest cacao-producing area in the West Indies, it is proposed to devote special attention to the circumstances of this industry. Proposals will be discussed for improving the cultivation, the use of suitable manures, the treatment of diseases, and the advantages, if any, to be derived in certain districts from the use of appliances for curing cacao by artificial heat.

This Conference will be more favourably placed as compared with previous Conferences, inasmuch as it will be possible to extend the business over a longer period and thus afford opportunity for a fuller consideration of the subjects to be brought before it. It will also be possible to visit several localities of special interest from an agricultural point of view and afford Representatives more time for the mutual exchange of ideas in regard to the possibilities of their respective colonies.

I am glad to find that in point of numbers, as well as in the standing and experience of the members accredited to it, this Conference compares favourably with any of its predecessors. We have amongst us able and representative men who not only possess a direct interest in the welfare of these colonies but who are in a position to speak with authority in regard to the many questions to be submitted for their consideration. We have also present men highly qualified in their special departments, who by their scientific skill and knowledge are capable of dealing successfully with complex and difficult problems and placing the results in a practical form at the disposal of the planting community. It is the cordial co-operation of these two forces (which all along has been one of the main objects of these Conferences) that will make for the ultimate salvation of these colonies. I believe that I am justified in stating that we have now assured to us the confidence and support of all the prominent men who represent the practical side of agriculture. They are working side by side in hearty co-operation with the scientific side, hence the results cannot be otherwise than beneficial and of a lasting character.

The Fruit industries of Jamaica, Barbados, Trinidad, and other parts of the West Indies will be brought under review, and it is hoped that the information to be placed before the Conference will be the means of solving some of the difficulties that have hitherto been met with.

The Cotton industry appears for the first time on our list of West Indian industries. We have now arrived at a period

when it may be possible to form an approximate estimate of the prospects of reviving cotton growing in these colonies.

Among general subjects there are several of an interesting character such as the present position of Rice growing in the West Indies, the possibilities of Rubber cultivation, the treatment of Anthrax and other diseases in stock, the Cocoa-nut industry, the relative merits of Hairy Sheep as compared with other sheep in the West Indies, and the establishment of Agricultural Banks.

The treatment of the diseases affecting crops continues to receive a large share of attention. There is no doubt that in most cases where diseases have made their appearance, and where remedial measures have been immediately taken in hand, the loss to the planter has been either prevented altogether or greatly reduced. Proposals put forward for fumigating plants before they are admitted into these colonies are being generally carried out. This is one of the most effective means for preventing the introduction of insect pests. Disinfecting large importations of seed, as was done in the case of Sea Island cotton seed during last season, is a precaution that deserves to be generally adopted.

At former Conferences a prominent position has been given to proposals for introducing the teaching of the principles of Agriculture into the Primary and Secondary Schools in the West Indies. The progress in this direction has necessarily been somewhat slow; but, on the whole, sufficient experience has now been gained to enable us to look hopefully as to ultimate success. The information to be placed before us by those who have taken an active part in this work cannot fail to be of interest. It is impressed upon us as a matter of daily experience that, until the mass of the people in the West Indies are brought into sympathy with agricultural pursuits and are trained from infancy to adopt the successful treatment of the soil as the basis upon which to build not only their own prosperity but the general prosperity of these colonies, we cannot regard ourselves as fully equipped for competition with other countries.

SUGAR INDUSTRY.

From a recent report presented by Professor Harrison in behalf of the Sugar-cane Experiment Committee of the Board of Agriculture, it would appear that the total area under cultivation in sugar-cane in British Guiana is 78,003 acres, including 2,500 acres cultivated by small farmers. This is an increase of 11,095 acres as compared with 1896. The average cost of producing 1 ton of first centrifugal sugar, including 14 per cent. second sugar and 25 gallons of rum, was £10 9*s.* 2*d.* in 1903 as compared with £11 9*s.* 2*d.* in 1896. In 1897 only small areas of land were occupied with canes of other varieties than Bourbon, while at the present time about 14,000 acres are planted with them. The result of experiments on a large scale with seedling and other canes than Bourbon recorded during the last three years 'indicate an increased yield per acre of from 12 to 20 per cent. over that of the Bourbon.' The Committee states that this increase has been

obtained by the substitution of certain new varieties for the Bourbon cane 'without increase in the cost of cultivation and possibly with a lessened outlay for manure.' It is added that 'in many of the experiments the varieties, other than Bourbon, have been cultivated on land on which the latter cane does not flourish, while the Bourbon returns are, as a rule, from land of average fertility upon which it gives satisfactory returns.'

A 'Report on the Agricultural Work in the Experiment Fields and the Government Laboratory for the season 1903–4' in British Guiana has recently been issued by Professor Harrison.

The following are the principal varieties of other canes than Bourbon cultivated in British Guiana :— D. 109 (3,338 acres), White Transparent (2,876 acres), B. 147 (1,138 acres), D. 625 (537 acres), and B. 208 (417 acres).

A general summary of the interesting results presented by the Sugar-cane Committee at British Guiana will be discussed later. As confirming what is stated by the Committee and as showing what has been done with seedling canes on a large scale at the Diamond Estate in British Guiana, the Manager states, as the result of experiments carried on for four years (1901-4 inclusive), that seedling canes grown on an average area of 1,537·918 acres, as compared with Bourbon canes grown on an average area of 2,824·352 acres, have proved better than the Bourbon to the average extent of 24 per cent. The average crop reaped during the period under review was 10,560 tons of sugar. The details on which this summary is based are now before you.

At Barbados during the last five years 20,407 varieties of seedling canes have been raised. Less than 1 per cent. of these have stood the stringent tests of field and chemical selection applied to them. The seedling experiments in hand up to December 31, 1903, consisted of 8,120 plots covering 143·294 acres. Experiments with manures consisted of 106 plots covering an area of 14·196 acres, while another set of manurial experiments consisted of eighteen plots covering an area of 16·02 acres. The general results are favourable and indicate that the efforts that are being made are in the right direction and justify the opinion that the raising of seedling canes affords special promise, as in British Guiana, of increasing the yield and diminishing the cost of cane sugar production in this island.

About 35,000 acres of canes are reaped annually in Barbados. According to a return prepared by Mr. Bovell in 1903, the Bourbon cane, owing to the prevalence of disease, has been almost entirely discarded of late years. The area under cultivation in this cane in 1903 was 328 acres. The area under other canes in 1903 was approximately as follows : White Transparent, 18,566 acres ; Rappoe, 3,089 acres ; Caledonian Queen, 1,661 acres ; B. 147, 1,612 acres ; B. 208, 342 acres. The area under seedling canes is gradually extending. The figures for 1904 are not yet available. Of the newer canes the most promising is B. 1,529. The cultivation of this cane (on account of the large yield, per

acre and the purity of its juice) is being extended to as many experiment plots as possible during the present planting season.

The reason why seedling canes have not been adopted on a larger scale at Barbados is due to the high standard of excellence attained in that island by the White Transparent cane. But every year the results of the seedling experiments show an approximation to the establishment of a richer and more stable variety. In the meantime, the conjoined efforts of the Department and members of the planting community are steadily being directed to the general improvement of the industry.

A Pamphlet (No. 32) containing a summary of the last Report on 'Seedling and other canes at Barbados, for the year 1903-4,' prepared by Professor d'Albuquerque and Mr. J. R. Bovell, is now before you.

In the Leeward Islands Dr. Francis Watts has recently presented the results during the last five years in regard to the introduction of seedling canes and manurial experiments at Antigua and St. Kitt's.

At Antigua there are about 8,000 acres under cane cultivation. The principal varieties are the White Transparent (under which is included Naga B., Mont Blanc, and Caledonian Queen), B. 147, D. 95, and B. 208. The area under Bourbon is reduced to about 204 acres. By means of the introduction of new varieties of canes, Dr. Watts states, 'the planter has now an opportunity of selecting his canes for particular soils and situations or for early or late planting. In this way he may not necessarily select that cane which has done best on the average of the whole of the experiments, but his own observation may have led him to see that some particular cane will prove suitable for some special conditions and he selects suitable canes accordingly.'

At St. Kitt's the total area under canes is estimated at 7,000 acres. The principal canes cultivated are what are known as the 'Jamaica', Caledonian Queen, and White Transparent. The area under seedling cane B. 147 is about 1,700 acres and under B. 208, 130 acres. The area under Bourbon is about 340 acres.

At one time cane diseases in this island 'invaded one area after another until fears were entertained that some estates must be abandoned and sugar growing cease upon them. Following the advice of the Department of Agriculture those planters whose canes were being destroyed by the ravages of disease introduced other varieties, notably B. 147, with the happiest results: plantations which were in danger of abandonment are now bearing luxuriant crops to the great relief and satisfaction of their owners.'

In summing up, Dr. Watts states: 'it will be seen that the newly introduced varieties of canes, including some of the newly discovered seedlings, have already played an important part in the sugar industry of the Leeward Islands. The work of their introduction is highly regarded by planters who freely express their appreciation of the advantages they have derived,

and the feeling is now engendered that in the selection of varieties of cane they are in possession of a powerful defence against many forms of cane diseases.'

A pamphlet (No. 33), containing a summary of the results of the cultivation of 'Seedling and other canes at the Experiment Stations in the Leeward Islands during the year 1903-4,' is in the press and will be issued shortly.

At Trinidad the Otaheite or Bourbon cane is generally cultivated. Owing to the absence of serious disease and to the generally good results obtained from the present canes, systematic experiments on large estate scale with seedlings and manures have apparently not been regarded as a necessity, as in the other colonies. Seedlings raised locally, or obtained from elsewhere, have been grown for some years at St. Clair Experiment Station and the canes analysed by the Government Chemist. The recent results are published in the *Proceedings* of the Agricultural Society and the *Annual Reports* issued by the Botanical Department.

At Jamaica during the last three years Mr. H. H. Cousins has undertaken manurial experiments on estates on a fairly large scale. The results have shown that Jamaica soils are generally well suited for cane cultivation. About eighty selected varieties of cane are being grown at the Experiment Station at Hope for distribution. It is now proposed to inaugurate a scheme of sugar work on a large scale. A law was passed by the Legislature in August 1903, by which the Imperial grant-in-aid of the Sugar Industry (£10,000) was appropriated for the maintenance, under the direction of Mr. Cousins, of Experimental Stations with special reference to the chemistry and mycology of sugar and rum. A Fermentation Chemist has been appointed in connexion with the rum investigations. The grant is estimated to provide for research and experiment work for six years.

In regard to the sugar-cane experiments carried on in the West Indies, it may be mentioned that the numerous publications issued, as well as the new canes raised, appear to be highly valued in other countries. For instance, the Director of Sugar-cane Experiments at Hawaii states that 'cane D.117 yielded from a ton to a ton and a half more sugar to the acre than any other variety under trial.' In Cuba Mr. E. F. Atkins, of Grand Soledad, reports that cane D.95 gave highest polarization and purity. B. 208 (from short 2nd. plants) led in this respect but was deficient in juice. Mr. Robbins, of Port Douglas, Queensland, mentions that B.147 headed the list, yielding 23·40 per cent. of 'possible obtainable crystallizable sugar' from ratoons. In Louisiana the best seedling canes in experiments carried on by Dr. Stubbs were D.95 and D.74.

The exports of selected cane tops from Barbados are considerable: a recent set of shipments to a neighbouring island consisted of 20,000 plants.

CACAO INDUSTRY.

A review of the Cacao Industry in the West Indies was published in the *West Indian Bulletin*, Vol. V, pp. 172-7. It

would appear that the total exports of cacao from these colonies have risen from 335,817 cwt. in 1898 to 494,873 cwt. in 1902. These figures indicate that cacao plantations are being very considerably extended throughout the West Indies. The exports of cacao from Trinidad are of the annual value of £1,000,000. Those of Grenada are of the annual value of £250,000. Jamaica comes next with exports of the annual value of £80,000. It is estimated that about 80,000 plants, besides large quantities of pods, are being distributed from the Botanic Gardens and Experiment Stations every year. The diseases affecting cacao continue to receive careful attention, and planters are kept fully informed as to their character and treatment. So far the 'Witch Broom' disease, that has so seriously crippled cacao estates in Surinam, has not reached the West Indies. It is desirable that the recommendations made by the Imperial Department of Agriculture with the view of keeping out this disease be continued.

The results of experiments with the view of improving the general health and the yield of cacao plantations will be discussed later.

COTTON INDUSTRY.

The first of the recent experiments in cotton growing were started at St. Lucia in 1900. In the following year these experiments were extended to Barbados and the northern islands. In 1902 Messrs. Sendall and Wade began the cultivation of cotton on a commercial scale at St. Kitt's and Montserrat. The total area planted in all the islands in 1902 was 500 acres. This was increased in 1903 to 4,000 acres. During the year 1904 the area planted in Sea Island cotton, and now coming into bearing, was 7,243 acres, and in other varieties 4,438 acres, making a total of 11,681 acres. Valuable assistance was rendered by the British Cotton-growing Association in making grants of money and machinery; also in taking charge of the shipments of cotton and finding the best market for them. More recently the Association arranged for a visit to the West Indies by Mr. E. Lomas Oliver who rendered great service by explaining in detail the requirements of spinners in regard to uniformity in length of staple, colour, and fineness. The Imperial Department of Agriculture supplied 35,700 ℔. of seed of the best variety of Sea Island cotton at cost price. At present there are fifteen well-equipped cotton ginneries in working order. The prices obtained for West Indian Sea Island cotton during the past season have ranged from 12*d.* to 18*d.* per ℔. The average price was 14½*d.* per ℔. It is now recognized that West Indian Sea Island cotton is an article in good demand, and the industry shows every promise of being established on remunerative lines. It is probable that the crop of Sea Island cotton to be reaped from now to May next will reach about 5,000 bales (of 360 ℔. each) of the value of £100,000. Details in regard to the general position and prospects of the cotton industry will be laid before the Conference.

FRUIT INDUSTRY.

The very considerable fruit trade at Jamaica has been gradually built up during the last twenty-five years. Numerous difficulties had to be overcome, but the nearness of the New York market was an important factor in favour of the industry. Latterly, by means of the Direct Line of Steamers, a fruit trade is being established between Jamaica and the United Kingdom. The total value of the fruit trade of Jamaica in bananas, oranges, and other fruits is about £800,000 annually.

Naturally, the success of Jamaica has suggested efforts to establish a similar fruit trade in these eastern colonies. They are 1,000 miles nearer Europe, and many of them are very favourably situated for the production of fruit. The best means for shipping the fruit so as to enable it to be landed in good condition is a problem that has been under consideration for some time.

It is probable that, if the growers could obtain insulated and thoroughly ventilated holds by means of air shafts and fans on board the present Royal Mail steamers, Barbados bananas, packed in crates, might be successfully shipped during the winter and spring months, say, from October to June, without cool storage. But, with the exception of Barbados, which is the last port of call for the Atlantic steamers, it has been conclusively shown that cool storage is absolutely necessary for the shipment of fruit from all these colonies.

As an experiment, two of the Royal Mail steamers (the 'Tagus' and 'Trent') have been fitted with the Hall system of cool storage, and the results with bananas, when the fruit is carefully selected beforehand, and kept in a temperature between 60° and 65° F. have been uniformly satisfactory. If a sufficient quantity of fruit were grown for shipment, the Royal Mail Company might be induced to extend the Hall system to the other mail ships, and this might lead to further developments.

The subject is beset with difficulties, and it will require careful negotiation to be carried on for some time in regard to details before shippers find themselves in a position to obtain all their requirements. The first step necessary is to grow the right kind of fruit and produce it in such quantities and in such a condition as to meet the requirements of the market. Then would follow the arrangements for shipping it. In this matter it would appear that shippers must depend, for some time at all events, on the existing Royal Mail steamers. Afterwards, when the trade has assumed large dimensions, the company might be able to see its way to provide special steamers fitted with cool chambers capable of delivering large cargoes in good condition.

LIME INDUSTRY.

The exports of limes, concentrated lime juice and essential oils of limes from Dominica are of the annual value of £45,370. Lime juice and oils are exported from Montserrat of the value

of £5,810, limes and lime juice from Jamaica of the annual value of about £6,000. Trinidad also exports some lime juice.

This industry has occasionally been threatened by the attacks of scale insects, chiefly the purple scale (*Mytilaspis citricola*) and the orange snow scale (*Chionaspis citri*). It has been shown at Dominica that these insects can be kept in check by careful cultivation, including pruning and manuring the trees, and the use of insecticides. A small steam outfit for spraying lime trees has been introduced on one estate at Dominica with satisfactory results.

The manufacture of commercial citrate of lime has been investigated by Dr. Watts, and the results have been published in the *West Indian Bulletin*, Vol. II, p. 308 and Vol. III, p. 112.

IMPROVEMENT OF STOCK.

This is a subject that for a long period has received careful attention at Jamaica and Trinidad. It is now being generally recognized as an essential feature in the agricultural development of the West Indies. At British Guiana the Board of Agriculture has made an excellent start in this direction. The stock farm at Antigua is in course of being re-organized and improved. Considerable sums have been expended during the last six years by the Imperial Department of Agriculture in the purchase of pedigree animals for the purpose of improving local breeds in the smaller islands. Already there is a distinct improvement noticeable in some localities, especially in small stock such as sheep, goats, rabbits, and poultry. Dominica has taken up the improvement of ponies, and a small stock farm is attached to the Agricultural School. At St. Vincent a Hereford bull has proved very useful. At Barbados two stud goats, one presented by Baroness Burdett Coutts, were introduced two years ago. The progeny of these obtained prizes at the Agricultural Show on December 21 last.

SISAL HEMP INDUSTRY.

In districts where there are large stretches of moderately level, rocky or stony soils, with a low annual rainfall, say, 30 to 40 inches, it is probable that sisal hemp might become a successful industry. There are thousands of acres of land exactly suited for growing sisal hemp at Montserrat, Nevis, and the Virgin Islands. Full information in regard to the requirements of this industry has lately been published (*West Indian Bulletin*, Vol. V, pp. 150-72 and *Agricultural News*, Vol. III, p. 347).

In sisal hemp we have a crop which can be grown on poor and rocky land unsuited to other crops; its cultivation is a simple matter and reliable machines can be obtained for preparing the fibre. During the last ten years the price in the United States has varied from 1½*d.* to 5*d.* per ℔. The cost of production may be placed at about 1*d.* per ℔. to cover everything. A capital of £3,000 to £4,000 would be likely to be necessary to establish a plantation of 600 to 800 acres with the necessary buildings, machinery, etc.

RUBBER INDUSTRY.

The prospects of establishing plantations of India-rubber trees with the view of meeting the demand for commercial rubber will come before the Conference. Plantations of Pára and Central American and Lagos rubber trees require a rich soil and an abundant rainfall. There are undoubtedly large tracts of land in the West Indies capable of being planted with rubber trees. It will be interesting to learn some of the results of the experimental plantations already started by private enterprise at Trinidad and Tobago.

OCCURRENCE OF ANTHRAX AND OTHER DISEASES.

Papers will be presented on the occurrence of Anthrax and other diseases in cattle and horses for the purpose of obtaining a general review of the circumstances attending the appearance of these diseases and the methods usually adopted for dealing with them. This is a subject that does not appear to have been so fully discussed as it deserves in its bearing on agricultural progress. The losses that have been incurred in some colonies from these diseases have been very serious.

TOBACCO INDUSTRY.

This is a subject that continues to receive attention, but outside Jamaica little actual progress has been made in the production of first-class tobacco on a commercial scale. At Barbados, Antigua, and St. Kitt's, and, I believe, at Trinidad, tobacco is being grown to some extent for local consumption. It has been suggested that the services of a competent tobacco expert might be obtained to afford hints both as to the cultivation and curing of tobacco in the tropics. At Jamaica an experiment in growing Sumatra tobacco for wrappers under the shade of thin cloth was started last year by the Board of Agriculture. The results are full of interest. It is believed that as fine a grade of wrapper for cigars can be grown in Jamaica as that, hitherto, obtainable only from America.

BEE KEEPING.

There has been a distinct revival in this industry of late years. Honey is being produced in large quantities and the exports are appreciable. Bee supplies have been regularly kept in hand at the Botanic Stations and the students at the Agricultural Schools receive a sound training in bee management. Jamaica still holds the lead in the production of honey and wax. The exports in recent years from this island have reached a total value of £21,000. The pamphlet on 'Bee Keeping in the West Indies' (No. 9) continues to be supplied by the Agents of the Imperial Department of Agriculture.

FISH CURING.

The development of the fisheries of the West Indies was prominently brought before the Conference of 1901, and valuable information was published in the *West Indian Bulletin*, Vol. II, pp. 121-63. Since then, little or no advance has been made in regard either to investigating the extent and

value of the fisheries or their utilization on a commercial scale.

An interesting account of the 'Fishes of British Guiana' has recently been published by Mr. T. Sidney Hargreaves, F.G.S.

An attempt to establish a Fish-curing Factory at Barbados was started by the Imperial Department of Agriculture at the end of 1903. In a statement recently presented by Mr. G. W. Hunt, the Manager, it appeared that up to the middle of March 1904, 81,000 flying fish, in addition to quantities of other fish, had been purchased at the Factory, and 135 barrels of pickled and salted fish had been disposed of to date. The total expenses of the Factory were \$350·52; the cash sales amounted to \$163·99; the amount due for fish shipped to Demerara and Trinidad was \$174·00. The value of the fish in hand was \$160·00, making a total of \$497·99. This showed a credit balance in favour of the Factory of \$147·47 as the result of efforts during the first season.

AGRICULTURAL SHOWS.

Agricultural Shows are now a regular feature of agricultural life throughout the West Indies. In the larger colonies, such as Jamaica, British Guiana, and Trinidad, efforts in this direction are on a comprehensive scale. The trend of development in recent years has been in the direction of holding more local shows so as to enlist the interest of cultivators in the out-districts who had hitherto been overlooked. There is still a good deal required to be done to bring Agricultural Shows into immediate touch with the cultivators and stimulate them to grow and prepare produce possessed of special merit; and in the case of stock keepers to devote unremitting attention to the breeding and rearing of animals. The holiday side of Agricultural Shows is fully appreciated; but in too many cases the main object, for which alone they receive grants from public funds, is not sufficiently kept in view.

AGRICULTURAL EDUCATION.

Lecturers are now provided for teaching elementary science and the principles of Agriculture to the pupils at Harrison College, Barbados, the Jamaica College, Queen's College, British Guiana, and the Queen's Royal College at Trinidad, also for providing a course of instruction in Agriculture to the teachers in training at the Colleges at Jamaica and Trinidad. A Science Master is attached to each of the Grammar Schools at St. Kitt's and Antigua, and sixteen Scholarishps in Agriculture, of the value of £6 to £10, are attached to these schools. Two Scholarships of the annual value of £75 offered in the Windward and Leeward Islands are tenable at Harrison College.

The first series of lectures and demonstrations in Agriculture to teachers in charge of elementary schools were completed in 1902. A second series with special reference to the care of school gardens has since been carried out at St. Kitt's, Antigua, Barbados, and St. Vincent. At Jamaica the annual course of lectures to teachers with practical instruction at the Hope

Gardens is held in January of each year. Similar courses have been held at British Guiana.

School Gardens and School Shows have been established on a large scale at Trinidad. It is stated that nearly 200 Primary Schools are now provided with school gardens. Tobago has twenty-three school gardens. At Grenada there are thirteen school gardens and at St. Vincent ten school gardens. At St. Lucia only six schools are not provided with school gardens. In the Leeward Islands the first efforts have been in the direction of providing schools with boxes and tins for growing seeds and small plants under a system of pot culture. Plots for school gardens are provided at the several Botanic Stations, but the want of rain or the absence of water often militates against the success of these.

AGRICULTURAL PUBLICATIONS.

In all the colonies increased interest is shown in literature relating to agricultural subjects. At Jamaica the *Bulletin of the Botanical Department*, started in 1887, was changed in 1903 into the *Bulletin of the Department of Agriculture* with the view of extending its usefulness. The Jamaica Agricultural Society continues to issue its popular *Journal* started in 1897. The agricultural publications issued by the Government of British Guiana consist of yearly and half-yearly reports on the Agricultural Work in the Experimental Fields and the Government Laboratory, the Reports on the Botanic Gardens, and occasional reports on other subjects. The Trinidad publications are the quarterly *Bulletin* issued by the Botanical Department since 1888, and the *Proceedings* of the Trinidad Agricultural Society. The *Proceedings* of the former Grenada Agricultural Society have been discontinued, as also the *Agricultural Gazette and Planters' Journal* of the Barbados General Agricultural Society. The active Agricultural Society at Dominica issues an occasional Journal entitled the *Dominica Agriculturist*, edited by Dr. H. A. Alford Nicholls. In most of these colonies the press affords at all times a valuable means for the discussion of agricultural subjects, and devotes an appreciable amount of space to the diffusion of information bearing on local industries. The *Official Gazettes* are also utilized in this direction. The Imperial Department of Agriculture issues every fortnight a popular review entitled the *Agricultural News*, and a quarterly scientific journal, the *West Indian Bulletin*. Both these publications have a wide circulation amongst members of the planting community. It is proposed slightly to enlarge the *Agricultural News* and provide a coloured wrapper to preserve it for binding. In addition, there are issued Pamphlets on special subjects and Annual Progress Reports on the several Botanic and Experiment Stations, the Agricultural Schools and Agricultural Education. The total number of copies of publications issued by the Department during the year 1904 amounted to 76,200.

This is a brief summary of Agricultural progress during the period that has elapsed since the last Conference in 1902. The facts here stated will be confirmed and, in many particulars, supplemented by the information to be brought before us by

those present to-day, who have so ably taken part in the work. We have now passed out of the pioneering stage and we are in a position to present not only important results as affecting the sugar, cacao, cotton, fruit and other industries but to demonstrate that these Conferences, and the Department to which they owe their existence, are not only valuable to these Colonies, but that they also advance the general interests of the Empire. (Applause.)

The Hon. B. HOWELL JONES (British Guiana): I do not think that any of you would wish us to leave this room to-day without expressing our grateful thanks to Sir Daniel Morris, the President of this Conference, for the practical address he has given us summarizing the work that has been performed by the Imperial Department of Agriculture and the Boards of Agriculture which exist in the other West Indian Islands and Colonies. He has touched in his address on almost every subject that interests the planters—and in using the word 'planters,' I include those who are interested in what are known as the minor industries especially, because I think the Imperial Department of Agriculture has in the greatest degree assisted and helped those minor industries and encouraged those who have not the means, or large means, at their disposal to carry on vast sugar estates, which require a great deal of capital. It is for the encouragement of the small capitalists in the West Indies that the Imperial Department of Agriculture has become an extremely useful, and I may say an almost essential, part of the organization of the Government of the West Indies. We have lately heard politicians in England on the great principle of Imperialism. It is a thought which has existed long prior to these men who live in England, because I believe it has for many years always been felt deeply in the hearts of those who have been colonists that the Imperial idea would one day come to the front. And it is not only an Imperialism of politics, but an Imperialism of agriculture which will exist where an association exists such as we have in the Imperial Department of Agriculture in the West Indies. The principles of agriculture are exactly the same all over the world: they are not obtuse in any way. If there are any differences in the methods of dealing with various plants or fruits that are grown, it is local circumstances which introduce those differences. I remember Professor Wrightson addressing a large meeting of students at the Royal Agricultural College in Cirencester, in the course of which he said: 'Gentlemen, I have talked to you and instructed you in everything I possibly can on agriculture; but all I have told you and all I have endeavoured to instruct you is nothing if you do not take local circumstances into consideration.' And in dealing with the question of agriculture in the West Indies, each one of us must consider the local circumstances under which he works. It would be perfectly absurd for any one of us to say that such and such a thing has to be done to produce a crop simply because it happens to be done in the colony to which he belongs. In the neighbouring colony the circumstances may be entirely different, and that particular

class of agricultural work would be entirely unsuitable. We have met to-day, and we shall continue for the next ten days, to discuss amongst ourselves the work that has been performed by the Imperial Department of Agriculture, and to exchange ideas; and I think many of us will learn a great deal from what we shall see in visiting this beautiful island of Trinidad. It is called, as his Excellency has said, the 'Pearl of the Antilles,' and it has produced crops—cacao, sugar, and fruit—quite equal to any other part of the West Indies. Perhaps the sugar estates here are not so large as those in the colony to which I belong, but the men who conduct the sugar estates are quite in the forefront of everything that has been done in the way of sugar production. I feel there is one thing we should not forget, and that is the names of those who have gone before the present generation, whose names are deeply written in the pages of the history of agriculture in the West Indies, and who, although not assisted by science or scientific men have left a mark indelible on the agricultural history of these colonies. They were the pioneers of agriculture in the West Indies; they underwent hardships and, it may be, adopted rule of thumb methods; but the results obtained by them were not in any degree less than those obtained nowadays by the assistance of scientific observers and scientific men. I think this Conference regrets the absence of one who, by his high scientific knowledge and great attainments, has won the high esteem and respect of everyone who knows him. As the representative of the Board of Agriculture of British Guiana, I regret that Professor Harrison is not amongst us. Everybody respects his high scientific attainments and the way in which he disseminates knowledge among those who work with him. We in British Guiana thank Barbados for having allowed us to take away from them a man whom we look upon as second to none in the West Indies. I will not detain the Conference any longer, but will only say, in conclusion, that we thank Sir Daniel Morris for the address he has given us to-day, and we only hope that the results of the Conference will be such as to bring fruit and grist to the mill which we all serve—the Agricultural Industries. (Applause.)

The Hon. FORSTER M. ALLEYNE (Barbados): I wish to second most cordially the vote of thanks, which has been proposed by my friend Mr. Howell Jones, to Sir Daniel Morris. When Sir Daniel rises to speak we always expect to have a lucid exposition of what he has to say, and I think in this address which he has given us to-day, he has drawn up a most lucid and complete sketch of the work we have to do during the next ten days. I notice that there are exactly thirty-nine members of the Conference, and I hope that these thirty-nine articles will be able to draw up a sufficiently explanatory dictum of their faith, in order that we may proceed to elucidate the questions that he has put before us.

After the retirement of the visitors, the Conference proceeded with business.

The PRESIDENT announced that Dr. VAN HALL, the Director of Agriculture in the Dutch West Indian Colonies, had been

invited to attend this Conference as an hononary member, and he was sure they would join with him in welcoming that gentleman amongst them. He had further to announce that Mr. WALTER POWELL JEFFREYS, who took a great and keen interest in agricultural matters generally, had also been invited to be an honorary member of the Conference. To-morrow morning at 10 o'clock the Conference would resume its session, and he hoped that the members from Tobago and St. Vincent would have joined by then, and they would proceed to the consideration of subjects connected with the sugar industry. The matters to be discussed on subsequent days were stated in the programme which had already been circulated amongst members. The subjects, however, would not necessarily be taken in the order there given. The excursions which had been arranged by the Agricultural Society were also set down on the programme, and any alterations would be duly notified.

The Conference then adjourned until 10 a.m. on Thursday.

ABSTRACT OF PROCEEDINGS.

The regular business of the Conference was proceeded with on Thursday, January 5, at 10 o'clock.

II. SUGAR INDUSTRY.

The discussion on results of recent experiments with 'Seedling Canes and Manurial Experiments in the West Indies' was opened with a paper read on behalf of Professor J. B. HARRISON, C.M.G., by Mr. E. W. F. ENGLISH (British Guiana).

It was stated that 14,000 acres were occupied in British Guiana with varieties other than the Bourbon, and of these about 12,000 acres were being cultivated in new seedling varieties, the favourite varieties being D. 109, B. 147, D. 145, D. 625, and B. 208. In late years nearly one-third of a million tiny canes had been raised and 26,000 of these had been selected for field experiments. From these a few hundreds had been selected for continued experiments, and from these again the planters had selected some fifty varieties as being of possible value to them, and of that fifty some dozen or so showed promise of being of actual value agriculturally. There were indications that among the latest selection of seedlings were large-sized varieties of very high saccharine content. Practically every estate in the colony carried on small-scale experiments. But there was also a system of large-scale experiments which gave much more reliable results.

With regard to the manurial experiments, it would appear that the general principles were applicable not only to the Bourbon variety but also, probably, to all the new varieties submitted to experiment. The objects have been to determine the effects of the manurial constituents of plant food upon the yield of the sugar-cane, and to determine, if feasible, the effect of tillage, manuring, and cropping upon the proportion of the readily assimilable constituents.

Professor J. P. D'ALBUQUERQUE (Barbados) followed with a paper dealing with the results of the experiments carried on in Barbados. He referred to the pamphlet containing a summary of the results obtained in the experiments with varieties which had recently been issued and which was in the hands of the members of the Conference. B. 208 was still in favour with planters, and one of the newer canes, B. 1,529, had given very promising results. The principal results were indicated on the diagrams which were hung on the walls.

Dr. FRANCIS WATTS (Leeward Islands) gave a similar account of the experiments that had been carried on in Antigua and St. Kitt's. The full report of these experiments was in the press and would shortly be issued. Some of the varieties had shown a greater power of resistance to disease and drought than others. The charts on the walls showed clearly the results that had been obtained with various manures.

Dr. URICH, Analysist and Technical Chemist to the Trinidad Estates Co., Ltd., read a short paper on the comparative yield of the Bourbon cane, White Transparent, and D. 95 at Brechin Castle estate, Trinidad, in 1904. The results were obtained on the large area of 1,762 acres, and were therefore of considerable interest. D. 95 had given an average return of 23·65 tons per acre, as against an average of 21·23 tons per acre for White Transparent, and 16·43 tons per acre for the Bourbon. Dr. Urich was accorded a hearty vote of thanks for his paper.

In closing the discussion, the PRESIDENT said that it was too soon to generalize except to this extent, that seedling canes appeared in most instances to prove of very considerable value to the planters and to flourish under conditions unsuited to the Bourbon cane.

The subject of Cane Farming at British Guiana and Trinidad was then taken up.

The Hon. B. HOWELL JONES gave details of the cane-farming industry in British Guiana, mentioning some of the difficulties which had had to be overcome in the beginning; these were partly connected with transportation, and partly due to suspicion on the part of the labourer. The latter difficulty had been overcome by Mr. Scard who prepared a sliding scale of payment for canes which had been accepted as a standard.

Professor CARMODY dealt with the industry in Trinidad, giving statistics which showed that the industry had progressed and was now an established and important branch of the sugar industry. He concluded by making various suggestions for the improvement of the position of cane farmers.

The Hon. S. HENDERSON also addressed the Conference on this subject and gave certain facts and figures supplied by Mr. Peter Abel with regard to the cane-farming industry in the Naparima and Pointe-a-Pièrre districts between 1885 and 1490. These showed that the tonnage of canes per acre

obtained by cane farmers was being greatly reduced through want of cultivation and exhaustion of the soil.

His Excellency the GOVERNOR gave an interesting description of a system of cane farming which had given good results in Fiji. It was called the 'share' system or 'cane company' system. This was working so satisfactorily that the General Manager of the Colonial Sugar Refining Co., of Sydney, in whose hands practically the entire sugar industry of Fiji is placed, recently stated that he looked forward to the time, not immeasurably distant, when they would be able to reduce very largely indentured labour. A vote of thanks was accorded to his Excellency by the Conference.

The Conference then adjourned for luncheon.

Upon the resumption of business several questions were asked by members of the Conference of the various gentlemen who had read papers at the morning session.

Mr. L. LEWTON-BRAIN (Mycologist on the staff of the Imperial Department of Agriculture) then read a paper briefly reviewing the principal fungoid diseases of the sugar-cane, with special reference to the rind disease (*Trichosphaeria sacchari*), the pine-apple disease of cane cuttings (*Thielaviopsis ethaceticus*) and the root disease (*Marasmius sacchari*).

The subsequent discussion showed that the rind disease was prevalent in many parts of the West Indies but was practically confined to the Bourbon cane.

Mr. H. A. BALLOU (Entomologist of the staff of the Imperial Department of Agriculture) reviewed the insect pests of the sugar-cane. He dealt especially with a new pest that had made its appearance on one estate in British Guiana and was doing considerable damage. The insect may be known as the Larger Moth borer or *Castnia* of the Sugar-cane.*

Mr. A. W. BARTLETT and Mr. HOWELL JONES added certain information with regard to the outbreak of this pest.

The Conference then adjourned to enable the Representatives to pay a visit to the St. Clair Experiment Station under the guidance of Mr. J. H. HART, Superintendent of the Botanic Gardens.

The Conference resumed on Friday, January 6, at 10 a.m.

SUGAR INDUSTRY (CONTD.).

Dr. WATTS (Leeward Islands) read a paper on the 'Field Treatment of cane tops for planting purposes.' He described the experiments conducted at Antigua on the treatment of cane cuttings with germicides. The experiments consisted in treating the cuttings with Bordeaux mixture, in tarring the ends, and in a combination of these two methods. The results were of a decisive character and tended to show that Bordeaux mixture was an efficacious agent in preserving

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It has been identified as *Castnia licus*, Drury.

the cuttings; tarring the ends had also had a beneficial effect, though less marked. The use of Bordeaux mixture in conjunction with tar produced very slightly better results than Bordeaux mixture alone, but the slight gain did not warrant the extra expenditure on the tar. Bordeaux mixture was being fairly extensively used in this connexion at Antigua.

This subject was discussed by Mr. HOWELL JONES (British Guiana), Mr. ABEL, Mr HENDERSON, and Mr. FENWICK (Trinidad), the opinion being expressed that on large estates with several thousand acres under canes the number of tops was too great to permit of their being treated. Dr. WATTS replied that the magnitude of the operations could not be regarded as a barrier.

Dr. WATTS (Leeward Islands) then read a paper prepared by himself and Mr. H. A. TEMPANY (Assistant Chemist) on the 'Polarimetric determination of Sucrose.' The paper contained suggestions for securing greater accuracy and uniformity in results in work connected with sugar-cane experiments.

A further paper by Dr. WATTS on the 'Central Sugar Factory in course of being erected at Antigua' was then read. He described the circumstances which had led up to the erection of the factory, and briefly stated the position of affairs at the present time. The capital of the Factory Company was £40,000, including the £15,000 contributed by the Government. The Company agreed to erect a well-equipped factory capable of making 30 tons of 96° crystals in a day of twenty-three hours. It also agreed to purchase canes from peasant proprietors and others at prices to be regulated by a sliding scale fixed beforehand.

III. CACAO INDUSTRY.

Mr. HART (Trinidad) made a general statement of the experiments that had been carried out with a view to improving the health and productiveness of cacao trees. He referred especially to the methods of dealing with diseases of the cacao tree. With this end in view they had been trying to impress upon growers the great necessity for proper methods of pruning and cutting. Manuring had been adopted, in some cases with very good results.

A short paper, prepared by Mr. J. G. DE GANNES (Trinidad), was read by Professor CARMODY. So far, artificial manures had not been extensively used, but where they had been tried the results were encourging. Cacao in Trinidad had not suffered much from diseases; where they had appeared, with the treatment suggested by the Imperial Department of Agriculture, and the advice and assistance of Mr. Hart, planters had been able to keep them under control.

The PRESIDENT gave a brief account of the measures that had been adopted by the Department in Grenada, St. Lucia, and Dominica in rendering assistance to cacao growers by the establishment of sample plots in the outlying districts beyond reach of the Botanic and Experiment Stations.

Mr. HUDSON (St. Lucia) gave a sketch of the experiments that had been carried on in St. Lucia. The results were described as very satisfactory.

The discussion was carried on by Dr. NICHOLLS (Dominica), Dr. MORTON and Mr. DE GANNES (Trinidad), and Mr. FAWCETT (Jamaica). The last speaker inquired particularly as to the use of shade trees for cacao, and a valuable discussion followed in which many of the Representatives participated. The discussion went to show that the practice in this respect varied in the different islands. In Trinidad shade trees (usually the Bois Immortel) were practically always employed, and the opinion was firmly held that cacao could not be grown there without shade. On the other hand, in Dominica, Grenada, and usually in Jamaica also, no shade was employed.

The PRESIDENT said that the question could be settled only by actual experiment. He suggested that the Trinidad Agricultural Society might usefully undertake this.

In reply to the PRESIDENT, Mr. DE GANNES stated that in Trinidad the average yield from cacao trees was about 12 bags (of 170 ℔. each) per 1,000 trees, which were planted 300 to the acre. In Grenada, Mr. DE FREITAS stated, the average yield was 4 bags (of 196 ℔.) to the acre.

Mr. L. LEWTON-BRAIN (Mycologist on the staff of the Imperial Department of Agriculture) briefly summarized the chief facts with regard to the fungoid diseases of cacao. There were two stem diseases—the 'canker' disease due to a *Nectria* and the 'die-back' due to *Diplodia*. There were also two pod diseases—the 'Brown rot' due to *Diplodia*, and a black rot due to *Phytophthora*. He also described, more fully, a new disease, known as 'Thread blight,' that had made its appearance in St. Lucia. A description was given of the appearance of the disease and the methods of treatment that had been suggested. A short note on this disease was handed in by Mr. HUDSON (St. Lucia).

The PRESIDENT mentioned that a serious disease known as 'Witch Broom,' had appeared some time ago in Surinam. On account of the very destructive character of this disease, he had recommended to the various West Indian Governments that precautions should be taken to prevent its importation from the mainland of South America.

Dr. VAN HALL (Surinam) gave the Conference the results of his experiences with this disease, confirming the great loss caused by it to the planters. Spraying experiments had been commenced, but he could not as yet record any definite results.

Dr. WATTS (Leeward Islands) then read a paper on the manurial effects of green dressings and weeds in cacao cultivations.

The conference then adjourned for luncheon.

IV. FRUIT INDUSTRY.

After luncheon the PRESIDENT announced that the next subject to be taken up was the fruit industry. He had hoped

that papers would be brought forward dealing with the fruit industry in Jamaica and Trinidad. It was a large subject and could not be adequately treated in the short time at their disposal. Owing to the sad and sudden death of Mr. Symington, who was killed on the railway a few days before the Conference met, the paper promised by him on the fruit industry of Trinidad could not be presented. He proposed, therefore, to confine the discussion to the efforts that had been made at Barbados.

Mr. BOVELL (Barbados) read a paper describing what had been done in the matter of shipping fruit from Barbados. The shipments included, bananas, citrus fruits, avocado pears, golden apples, mangos, etc. He gave interesting statistics with reference to the cultivation and shipment of bananas. From January 1 to October 31, 1904, they had shipped 8,012 single bunches and 3,656 bunches in double crates.

Mr. FORSTER ALLEYNE supplemented the remarks of Mr. Bovell by figures in reference to the shipping of bananas from one of his estates. The bananas shipped from that estate, amounting to about 700 bunches, had netted 1*s.* 2*d.* per bunch.

In reference to this subject the PRESIDENT mentioned that he was told in England that the Barbados bananas were the finest that reached the United Kingdom. The industry had made fair progress, and everything had gone well until July of last year, when, on account of the warmer weather encountered by the steamers and the exceptionally large crop of English fruit obtainable, many of the planters had lost money, and some of them had been very much discouraged. They had, however, established the point that, if the fruit were carefully selected and well packed, and shipped in cold-storage chambers, there was little risk about its arrival in good condition. The 'Trent' and the 'Tagus' had been fitted with cool chambers, and they were in future prepared to ship their fruit by those steamers. He hoped that later the other Royal Mail steamers would also be fitted with Hall's system of cool chambers. He thought they should not be discouraged. They should remember that the fruit industry of Jamaica had taken something like twenty-five years to establish, during which the planters experienced great difficulties before they found themselves in a position to overcome them.

Dr. VAN HALL (Surinam) and Dr. NICHOLLS (Dominica) also took part in the discussion.

V. COTTON INDUSTRY.

Mr. BOVELL (Barbados) read a short paper on the position of the cotton industry in Barbados, reviewing the efforts that had been made down to the present time. This paper was supplemented by remarks from Mr. FORSTER ALLEYNE (Barbados) who gave some interesting figures in connexion with the profits of the cultivation of cotton on one estate in the island. The actual net returns, after payment of all expenses of cultivation, ginning, baling, and shipping, varied from £8 to £12 per acre. One planter, on the estate referred to,

with 22 acres of cotton, cleared at the rate of £16 12*s.* 7*d.* per acre.

Dr. WATTS (Leeward Islands) gave a summary of the results of cotton growing in the Leeward Islands. Experiments were started in 1902 with a view to determining the variety best suited to cultivation in those islands; these had shown that the Sea Island was the variety to which they could best direct their attention, and subsequent experiments had confirmed that decision. In 1903 hand-power gins were provided by the Imperial Department of Agriculture. In 1904 the Department, aided by the British Cotton-growing Association, had provided for Antigua a series of steam-power gins and baling presses. In St. Kitt's, Messrs. Sendal and Wade had carried on the industry on a large scale. In 1903-4 there were in St. Kitt's about 1,100 acres in cotton, in Nevis over 1,000 acres, in the small dependency of Anguilla 250, in Antigua 500, and in Montserrat 500 to 600 acres.

The Conference then adjourned till Monday, January 9, at 10 o'clock.

Upon the resumption of the ordinary business of the Conference, on Monday, January 9, the PRESIDENT recurred briefly to the cotton industry. At the previous sitting Dr. Watts had given an account of the cotton industry in the Leeward Islands, and it was not proposed to re-open the discussion. With regard to cotton growing in St. Vincent, Mr. Sands would prepare a statement which would be published in the proceedings of the Conference. A fine series of samples of Sea Island cotton, raised from Rivers' seed supplied by the Imperial Department of Agriculture, was exhibited from Trinidad, St. Vincent, Barbados, and St. Kitt's.

VI. GENERAL SUBJECTS.

The Hon. WM. FAWCETT (Jamaica) then read a paper on 'Raiffeisen Agricultural Banks.' He stated that Agricultural Loan Banks, on a popular basis, were much wanted in Jamaica, and probably, also, in the West Indies generally. He laid before the Conference the general principles which should serve as a guide in the formation of such banks, giving an account of the system of Government loans adopted in Jamaica as a measure of relief to those who sustained damages by the hurricane of August 1903. The success of these loans had greatly encouraged those who were desirous of attempting the establishment of peoples' banks on the model of that marvellous and admirable system invented by Raiffeisen in Germany more than fifty years ago. The details of the Raiffeisen system were given in his paper.

Mr. Fawcett's paper was discussed by Mr. HOWELL JONES (British Guiana), Dr. NICHOLLS (Dominica), Mr. COLLENS (Trinidad), and Mr. HARBIN (Grenada). The PRESIDENT offered the suggestion that the subject might be taken up and discussed in detail by the Agricultural Societies throughout the West Indies.

The PRESIDENT said the next subject on the agenda was a 'Review of the efforts to establish plantations of Rubber-yielding trees in the West Indies.' Captain Short, of Tobago, had, in conjunction with Mr. Orde, the Manager of the West India Rubber Syndicate's plantations, prepared a paper on rubber cultivation in Tobago. He gave the substance of the paper which showed that *Castilloa elastica* is practically the only rubber tree grown in that island, there being about 90,000 trees of this species growing there. A number of points in connexion with this cultivation were submitted to the Conference, including the possibility of the use of Castilloa trees as shade for cacao.

In the course of the discussion which followed, Mr. HART (Trinidad) expressed the opinion that a tree that itself required shade was scarcely likely to be of use as a shade tree for cacao. Mr. FAWCETT (Jamaica) said that in Jamaica Castilloa grew well without shade: and the PRESIDENT remarked that in British Honduras experience was in favour of this tree as a shade for cacao. Experience in the different colonies evidently varied, but at the next Conference more definite information would probably be available.

Mr. C. W. MEADEN (Trinidad) then read an interesting paper on 'Butter making at Trinidad.' As the result of experiments he was able to place before them a description of methods that had been the means of turning out a good marketable article capable of competing with any butter imported. Over 2,200 ℔. were made in 1902 which had realized £292. The samples submitted by Mr. Meaden were pronounced to be of excellent quality.

The discussion which followed was taken part in by Dr. WATTS (Leeward Islands), Professor CARMODY and Dr. MORTON (Trinidad), Professor D'ALBUQUERQUE (Barbados), Mr. HART (Trinidad), Mr. SANDS (St. Vincent), and the PRESIDENT.

The subject of 'Anthrax in the West Indies and the best means of controlling it' next occupied the attention of the Conference.

Mr. BALLOU (Entomologist on the staff of the Imperial Department of Agriculture) opened the discussion by giving a brief account of the disease and its occurrence in the West Indies. He read extracts from a paper prepared by Dr. C. W. Branch on the outbreak of Anthrax in St. Vincent in 1902, showing serious loss in cattle and many deaths among the labouring class. Dr. Branch urged (1) the necessity of educating public opinion as to the danger of eating unsound meat; (2) the stringent prohibition of the flaying of any animal, except such as are regularly slaughtered for food; (3) the dissemination of information about the disease. Mr. HOWELL JONES gave interesting information in connexion with the treatment of anthrax in British Guiana. Mr. DUNCAN MILLER, Government Veterinary Surgeon, Trinidad, was invited by the President to give an account of the precautions taken in Trinidad with reference to the prevention of this disease. He advised notification, disinfection of premises under proper

supervision, vaccination if disease is rife, three weeks' quarantine for diseased importations, and complete destruction by fire of all carcasses of animals dying from anthrax.

Dr. NICHOLLS (Dominica) and Mr. WILLIAMS (Jamaica) also contributed to the discussion on this subject.

The Conference then adjourned until Wednesday, January 11, at 9.30. An extra session was to be held on Friday, January 13, for the consideration of further papers on general topics.

VII. EDUCATIONAL.

On re-assembling on Wednesday, January 11, at 9.30 a.m., the PRESIDENT said they would take 'the Results of efforts to introduce the teaching of the principles of Agricultural Science into the Colleges and Secondary Schools in the West Indies.'

The discussion was opened by a valuable paper by Mr. HORACE DEIGHTON (Barbados) who dealt with the work of the Imperial Department in Barbados from an educational point of view. Science teaching had been carried on at Harrison College, for some time prior to the arrival in Barbados of Sir Daniel Morris, by the Island Professor of Chemistry and his Assistant. In 1899 a Lecturer in Agricultural Science was provided by the Imperial Department of Agriculture, and efforts were made to take all the advantage possible of so liberal an appointment, the science curriculum being entirely remodelled. The amelioration of the condition of the West Indies was to be attained by a proper education, and that education could now be obtained at Harrison College, owing in great measure to the valuable assistance afforded by Sir Daniel Morris. Mr. Deighton also referred to the work of the Department in promoting an intelligent interest in the cultivation of fruits and vegetables among the peasantry by means of lectures to teachers of primary schools and by local agricultural exhibitions.

Professor D'ALBUQUERQUE (Barbados) also dealt with the subject of agricultural education at Harrison College and referred for details to his paper in the *West Indian Bulletin* (Vol. I, pp. 94-100). The sketch there given had since been fully carried out.

The PRESIDENT remarked that the point he wished to dwell upon when he introduced the system was that a boy must have a good sound general education before he specialized in scientific agriculture.

Dr. WATTS (Leeward Islands) mentioned what had been done at Antigua and St. Kitt's to assist the Grammar Schools by the appointment of Science Masters. The plan adopted at these schools was to allow the boys, at a comparatively early age, to elect whether they should take up elementary scientific studies or depend entirely on classical subjects.

Mr. ENGLISH (British Guiana) made a short statement as to science teaching at the Queen's College and at the Government Laboratory. This was almost entirely confined to chemistry.

Professor CARMODY (Trinidad) followed with a paper on 'Higher Agricultural Education in Trinidad.' He read the

report of a Committee consisting of the Principals of the three colleges and himself, nominated on July 7 last, to discuss and formulate a scheme in respect of the teaching of Agricultural Science at the Colleges. Attempts had also been made to introduce higher Agricultural Education by providing a course of instruction at the Government Laboratory and by a series of lectures at the Victoria Institute.

Mr. J. R. WILLIAMS (Jamaica) read an interesting paper, which was greatly appreciated by the Conference, on 'Popular Agricultural Education in Jamaica.' During the last few years there had been a steadily increasing effort to promote agricultural education both in the schools and outside of them. They had learned the importance of preparing the ground by creating interest and sympathy in the work amongst the adult population and of doing all that could be done to equip the teachers for the new requirements imposed upon them.

In the training colleges additional importance had been given to science subjects, particularly elementary agricultural science; opportunities had been given the last few years for teachers actually employed in the schools to obtain a few weeks' special agricultural training.

In the second place the operations of the Jamaica Agricultural Society must be very largely credited with the improvement in popular agricultural education. Last year there were forty-one local branches scattered all over the island, with a total membership of 2,563.

Mr. J. H. COLLENS (Trinidad) read a paper on 'School Gardens and School Shows in Trinidad.' He gave an account of what had been attempted with regard to school gardens, and stated that they were endeavouring to give that form of education which would go to the making of good citizens in country districts. With regard to School Shows, a beginning had been made in a small way in January 1902, when a School Garden Show was held at Port-of-Spain. The next year local shows were held at Couva, Tunapuna, and Princes' Town. In the following year the Tobago schools entered into the scheme. Each year the increased number of schools taking part and the improved quality of the exhibits have afforded a convincing proof of the utility of these annual exhibitions.

Mr. HARBIN (Windward Islands) read a paper on 'Agricultural Education in Grenada and St. Vincent in 1902-4.' He was assured that in the matter of school gardens a fair start had been made, and that, with the remedying of certain defects, the school gardens of Grenada and St. Vincent would in the near future compare favourably with those of other colonies. He was satisfied that the foundation of agricultural teaching had been laid in the upper standards of the primary schools, and in this connexion the inclusion of plant life and kindred subjects in the object-lesson courses had proved very useful. He believed that another period of three years would find the undercurrent of opposition, which was so well known to characterize the first appearance of the teaching of agriculture, entirely removed.

The subject of Agricultural Education, especially in relation to the work of Agricultural Instructors, was discussed by the PRESIDENT, Mr. FAWCETT (Jamaica), Dr. MORTON (Trinidad), Mr. HOWELL JONES (British Guiana), Mr. HUDSON (St. Lucia), Dr. WATTS (Leeward Islands), and Dr. NICHOLLS (Dominica).

The Conference was then adjourned to allow the members to attend the sale of stock at the Government Farm. The PRESIDENT announced that the Conference would meet again on Friday morning, when there would be an opportunity for a further discussion on the subject of cane farming.

CONFERENCE DINNER.

The members of the Conference dined together at the Queen's Park Hotel on the evening of Wednesday, January 11, at 8 o'clock. The arrangements for the dinner were in the hands of a committee appointed for the purpose consisting of the Hon. B. HOWELL JONES, the Hon. WILLIAM FAWCETT, the Hon. FRANCIS WATTS, Professor D'ALBUQUERQUE, and Mr. W. R. BUTTENSHAW (Secretary). The President of the Conference (Sir DANIEL MORRIS, K.C.M.G.,) occupied the chair. Covers were laid for fifty-one. In addition to all the members of the Conference, except the Representatives from Grenada, St. Vincent, and Tobago, who had been obliged to leave Trinidad during the afternoon, there was a large number of guests including the following :—

His Excellency, Sir HENRY M. JACKSON, K.C.M.G., Governor; the Hon. HUGH CLIFFORD, C.M.G., Colonial Secretary; Lieut. Colonel H. E. BRAKE, C.B., D.S.O., Inspector General; his Grace ARCHBISHOP FLOOD; Mr. Justice SWAN; the Hon. W. C. L. DYETT; and Lieutenant HANKEY, A.D.C. His Honour the CHIEF JUSTICE and his Lordship the BISHOP were unavoidably absent.

Dinner over,

Sir DANIEL MORRIS rose and proposed 'The King', which was drunk with the accustomed honours.

Sir HENRY JACKSON then rose and said: Your Grace, and Gentlemen—It is my good fortune to have to propose a toast which needs no words from me to commend it to you, and that is 'The Success of the Imperial Department of Agriculture for the West Indies and the health of its distinguished President.' (Cheers.) The separate parts of the toast I feel go together, for I am sure that as long as the President retains his health and vigour, there is no doubt whatever of the success of the Department. It is not very many years since the Department came to the West Indies, but if we go by results, a very great deal has been done which would have taken many departments very many years to accomplish. (Cheers.) The Department was formed to meet the needs of the

West Indies when they were in a very bad way, and to help them to establish other industries which might tide them over the time until the sugar industry could resume its place. It has done that thoroughly well, and many industries have been assisted by its advice. I can speak with feeling on this because it is not only in Trinidad that I have benefited by their advice and help. In the Leeward Islands, where I was for a very short time, I tried to do my best to help in the establishment of Central Factories. (Renewed cheers.) I worked very hard but I could not have done what I did without the assistance of my friend Dr. Watts. (Cheers.) Though I was there too short a time to carry to a successful issue what my successor was fortunate to accomplish, yet I know he will acknowledge his debt to Dr. Watts, and the great Department which has so greatly helped us throughout the West Indies. Not only as regards sugar but other industries the Department has given very material help. It fell to my lot to open the proceedings of the Conference, and I endeavoured on that occasion to express my gratitude and the gratitude which I am sure was felt throughout this colony towards the Imperial Department of Agriculture (cheers); but I was sorry when I read my own remarks next day to find that I had left out exactly what I wished most to say. (Cheers.) I tried then to say what help the Department had given us, and how they were always ready to advise us; but I left out what is of exceeding value not only in the West Indies but throughout the world, and that is, the value of their publications. (Cheers.) When I needed advice on the other side of the world, I turned to the *West Indian Bulletin*, which was sent me by the kind generosity of the Head of the Department, and there I generally found something to help the people along. Not only does the Department advise here but throughout the British colonies and beyond. I can say from my own experience that that advice is most useful. In Fiji we had a fruit industry and the trees were suffering from disease; I found in the *West Indian Bulletin* the exact disease described and means of treatment suggested. Therefore, on the other side of the world the publications of the Department are doing good. They have the widest range possible. They combine the results of the efforts of the practical agriculturist as well as of the trained scientist in botany and chemistry, and I should be afraid to say how many other things besides. I am surprised at the range of the work undertaken by the Department. I have read many interesting articles in the *Bulletin*: I was reading to-day about the birds of Barbados; and only a day or two ago I was talking to the distinguished Commissioner, and he informed me that fishing and fisheries came within the purview of the Department's work. I had thought that fisheries could not come within the scope of a Board of Agriculture (cheers and laughter), but I remembered that I had been for a time stationed in Newfoundland and there they used fish for manure. (Applause.) That being so, I do not know where the Department will stop—what branch of science it will not be called upon to take up. But there is one

thing of which I am sure, that whatever branch it is called upon to take in hand or investigate, it will help us with the same success that has attended its efforts in other branches. Therefore I ask you to drink to the health of Sir Daniel Morris, and the success of the Department over which he presides. (Applause.)

The toast was drunk with much enthusiasm.

Sir DANIEL MORRIS (who on rising to respond was greeted with cheers) said: Your Excellency, Your Grace and Gentlemen. I am deeply touched by the very kind way in which the toast so eloquently proposed by Your Excellency has been received in this distinguished company, especially as after the lapse of six years it is possible to form a tolerably good idea of the nature of the work entrusted to the Department, and the measure of success that so far has been attained. Thanks to the strenuous efforts of the band of workers I see around me to-night the success of the Imperial Department of Agriculture is assured. It is receiving the hearty support of all classes, and I am convinced that during the next year or two the great utility and influence of the Department will be still more widely recognized.

This is our fifth Conference. The value of these gatherings is becoming more apparent year by year. They serve not only to draw together a number of highly qualified men directly interested in agriculture but the information acquired at these Conferences enables them to overcome difficulties that would otherwise dishearten and exhaust them. I greatly appreciate the action taken by the several Governments in appointing able and accomplished representatives to attend this Conference; to those who have travelled some hundreds of miles in order to contribute their share of knowledge and experience I am most grateful: and especially for the hearty and cordial manner in which they have assisted me in the business of the Conference. We are fortunate in seeing amongst us a larger number of representatives of Boards of Agriculture and Agricultural Societies than on any previous occasion. We have in many respects quite a unique and unprecedented gathering in the agricultural history of the West Indies. There are several un-official gentlemen occupying distinguished positions like the Hon. Howell Jones (of British Guiana), the Hon. Forster Alleyne and Mr. Deighton, the distinguished head of Harrison College (of Barbados); Dr. Nicholls (of Dominica); Mr. Fenwick and Mr. Abel (of Trinidad) and many others. Amongst the official representatives we have Mr. Fawcett (of Jamaica); Dr. Watts (of the Leeward Islands); Professor d'Albuquerque and Mr. Bovell (of Barbados); Professor Carmody and Mr. Hart (of Trinidad), and the officers of the Imperial Department of Agriculture, all devoted and zealous men who are doing most valuable work for the good of these colonies. As a result of the presence of these gentlemen, I believe our deliberations on this occasion have been more fruitful than otherwise they would have been, and we have come into closer touch with the requirements of the people. As I mentioned in my opening address we have been fortunate in having our meeting place in this beautiful and

fertile island of Trinidad. We have been received both by Your Excellency, by the members of the Government Departments with whom we have come into contact, as well as by the planters generally, in the most cordial and helpful mannre. In fact, our reception everywhere has had in it the true ring of West Indian hospitality, and we shall long cherish the recollection of the very pleasant days we have spent in Trinidad. At the same time we have not been forgetful that we are here in a common interest, viz., for the purpose of advancing the whole industrial interests of the West Indies.

I again thank Your Excellency, Your Grace, and Gentlemen for the cordial reception at your hands of the toast of success to the Imperial Department of Agriculture, and I trust that the Conference of 1905 will still further weld together the practical and scientific forces existing in the West Indies and that we may crown our efforts by securing a large share of happiness and success to the inhabitants of these colonies. (Applause.)

His Grace ARCHBISHOP FLOOD: I have had a distinguished honour conferred upon me, by being invited by the gentlemen of the Dinner Committee to propose a toast that perhaps is not second to the one which we drank so enthusiastically just now, and that is. 'the Health of our Visitors.' (Applause.) Hospitality is a virtue that has been long known and practised in Trinidad; but I shall not for a moment attempt to say we have a monopoly of that virtue: it is a virtue of all the West Indies. (Cheers.) The West Indies have had their trials; they have had volcanic eruptions and hurricanes and sugar bounties (cheers and laughter) and all the other evils of life; but in spite of them all, they have ever upheld, in bright times and bad times, the name for generous, cordial hospitality. In fact, the hospitality of the West Indies, and especially of the West Indian planters, has gone into a proverb. (Cheers.) I do not speak of a thing that I do not know anything about. Although I live in Trinidad, I have gone about a good many of these colonies, and I know a lot about them; and though an old man as I am, who realizes the discomfort of leaving his own home and travelling abroad, still I feel that even those discomforts are more than compensated for by the cordial welcome I get in all the West India Islands which I visit. (Cheers.) Therefore, in Trinidad I do not say you have a monopoly, but I do say that Trinidad stands foremost in the ranks of hospitality in the islands of the West Indies. (Applause.) We are always glad to receive visitors here. But to receive such distinguished visitors as the present is a high honour indeed and a great pleasure. (Applause.) These are no ordinary visitors we are receiving at the Agricultural Conference: we are receiving men of high scientific attainments, of wide practical experience; men that all the West Indies have to look up to for light and guidance in agricultural matters, and any island or place would be honoured by the visit of such gentlemen as those I see around me this evening. (Cheers.) And when we think of what these gentlemen have come here to do—they have not come to amuse themselves, but to work as they have been working all these days, they have come here to teach us things which we did not

know already. I see Professor Carmody looking hard at me (laughter), so also is Mr. Hart (renewed laughter), but I still say we have a great deal more to learn. (Cheers.) I must say I read with great interest the proceedings of the Conference appearing in the newspapers, but I hope, too, to read it in the *West Indian Bulletin*, copies of which Sir Daniel Morris regularly sends me. I am quite at one with Sir Daniel Morris in his idea that these Conferences will knit more closely together all the West India Islands, and that the discussions which take place at them must be to the advantage of all. There is no doubt whatever that for the last six years these Conferences have done an immense amount of good, and for the next five or six years they will do more. I must repeat, we owe a deep debt of gratitude to the visitors; we received them with joy, and we will part with them with regret. (Applause.) I now propose the visitors, their happy departure and their speedy return; and with the toast I beg to associate the names of Mr. Forster Alleyne, of Barbados, Dr. Nicholls, of the Leeward Islands, and Mr. J. R. Williams, of Jamaica. (Applause.)

The toast was drunk with the utmost enthusiasm.

The Hon. FORSTER M. ALLEYNE (Barbados), in responding, said: The Archbishop has poured upon us a flood of eloquence which I am unable to beat, but I should like to say that I consider I am not the right man in the right place. I think the right man to respond to a toast like this should have been Dr. Watts who has been, I may say, one of the mainsprings of the speakers of the Conference. Hardly a subject has been brought up at the Conference on which Dr. Watts has not been called upon to speak, and I need hardly say there is not a subject he has touched which he has not adorned. (Cheers.) I think the old Dr. Watts, whom we all knew in our childhood, must have had a prophetic eye towards the young Dr. Watts (laughter) when he wrote those happy lines—

'How doth the little busy bee
  Improve each shining hour,
By gathering honey all the day
  From every opening flower.'

(Applause.) That seems to me the most absolutely descriptive statement of what Dr. Watts' employment is. Long, I hope, may he pursue it. Well, gentlemen, what am I to say on behalf of the visitors? I have to say this. We came here prepared to do hard work. Sir Daniel Morris, before we came down, sent round a programme which was sufficiently ample, I think, and he hoped we would put our backs into it. We have had a good deal of hard work, but still the amenities have been more than ample. The people of Trinidad have treated us in a way that really no thanks can possibly be sufficient for. (Loud cheers.) We have had opportunities of looking over their industries, we have had excursions, we have had opportunities of looking over the most beautiful points of their scenery, and all of this at no expense of our own, and conducted with the greatest comfort to us and even luxury. (Cheers.) We thank them for this from the bottom of our hearts. And what have

we got to give them in exchange? We should like all of us,—I suppose, the wish that throbs in the heart of every delegate from each colony is that we could give to these men something in exchange for what they have done for us. But what can we do? We can show them plenty of canes growing in Barbados, but even to an owner like myself the prospect of sugar-cane palls after a time. (Laughter.) What have we got to give compared with your lovely palms? We have Mt. Hillaby, 1,120 feet above sea-level and canes growing at the very top of it. (Cheers and laughter.) The only thing I can say in favour of Barbados is this. We have done to Trinidad what no other colony has done—we have given you a Governor. (Prolonged cheers.) Sir Henry Jackson was born in Barbados and here he is now living and esteemed as the Governor of Trinidad. (Cheers.) That is what Barbados has done for you and that is all the thanks I can give you for what you have done for me. (Applause.)

Dr. H. A. ALFORD NICHOLLS (Dominica): In commencing any matter connected with the affairs of life, one likes to begin at the beginning; and the beginning of public speaking on this occasion was the speech delivered by his Excellency the Governor of this colony. I am glad to be able to say that one of my earliest and best friends in the West Indies was the father of your Governor. (Cheers.) I am also very glad to say that your Governor is a magnificent example of hereditary transmission: his father was one of the greatest orators of his age in the West Indies, and the speeches that this Conference has heard from his Excellency show that in regard to public speaking the son does not fall very far short of the father. (Applause.) I have now to come to matters connected with the Conference and the special subject on which I am called on to speak. We came to this island gladly, because we knew that Trinidad was one of the foremost islands in the West Indies. The earlier Conferences have all been held in Barbados, and Barbados, we all know, although a small island, is a most progressive one. It rejoices in the name of 'Little England.' It is an island which has reason to be proud of its progress and the position which it occupies in the Western Hemisphere. It has progressed not only in regard to matters of commerce, but in regard to matters to which we have given attention at this Conference, and I have only to say that the delegates from Barbados have not shown themselves in any way backward in what they have put before us, and the speech delivered to-night indicates that in regard to after-dinner speeches Barbados cannot be left very far behind. (Applause.) In Trinidad we have seen more than sugar cultivation and manufacture: we have seen cacao on fine estates. My friend on my left (Mr. Hoadley) has been able to show us not only his cacao plantation, but an improved method of preparing the bean for the market, and it is a great pleasure to me and the other delegates interested in cacao to see the way in which the celebrated Trinidad staple is prepared for the market. I have spoken of sugar and cacao, but I take it that the prosperity of these islands does not depend upon two products alone, so you

have to direct your attention to other agricultural matters which will assist in adding to the prosperity of your country. Of these the first to which I will allude is fruit. Our worthy and esteemed President, who perhaps regrets that he has not afforded me more opportunity of addressing the Conference and making my voice heard in that hall (laughter), has suggested to me that I should draw your attention to a letter that I received not long ago from one of the greatest scientific men living, a man who is at the head of the botanical world, a friend and fellow worker of the great Darwin—I refer to Sir Joseph Hooker. (Applause.) He wrote as follows: 'I still feel an abiding interest in West Indian matters and read Sir Daniel Morris' publications with interest. The time is, I think, in view when the banana will form an appreciable amount of the sustenance of the United Kingdom and an article of daily consumption among the poorer inhabitants.' It appears to me, therefore, not only from this dictum of one of the great men of to-day but also from my knowledge of the fruit trade, that there is a great future before us in providing this daily sustenance not only for the United Kingdom, but for the nations of the old world. (Applause.) I will now simply content myself with expressing the extreme gratitude of my fellow delegates and myself for the unbounded hospitality that has been extended to us by our good friends of Trinidad. (Applause.)

Mr. J. R. WILLIAMS (Jamaica): Many years ago, when Sir Daniel Morris was the head of the Botanical Department in Jamaica, he made the remark that pen keeping was a primitive form of agricultural industry. As I happen to be a pen keeper myself, you can understand the confusion I feel in being asked to respond in the presence of the most distinguished agriculturists in the Western Hemisphere. I feel, however, very proud, as the representative of the Jamaica Agricultural Society, to be asked to express our feelings to our hosts in Trinidad for the kind treatment we have received. The first thing that strikes one is the evidence of the strong feeling which prevails in Trinidad as to the proper relation between work and play. We have been here for a week, and four days' work has been tempered by three days' play. In responding to this toast, besides all the other organizations which seem to have done their best to entertain us, one must make special mention of the Trinidad Agricultural Society and the Secretary, Mr. Tripp. (Cheers.) Gentlemen, I will not detain you longer: there is only one other remark that I desire to make. I believe it is the pride and glory of Agricultural Societies, I believe it is what the Imperial Department of Agriculture specially looks forward to, to make two blades of grass grow where one grew before. Here in Trinidad your Society is going to have the much higher glory of making two agriculturists grow where one grew before. I have been sent as the Representative of the Jamaica Agricultural Society. I have, I believe, thirteen brethren on the Board of Management, and I am sure, when I return to Jamaica, the whole thirteen will want to come to the next Conference. (Applause.)

The Hon. B. Howell Jones (British Guiana) : It is an honour I feel very much in being asked as the representative of the Conference to propose a toast which the members of the Conference will, I am sure, receive with unbounded enthusiasm. I propose the toast of the 'Health and Welfare of the members of the Agricultural Society of Trinidad and of the Entertainment Committee.' (Cheers.) I may say, without the shadow of doubt, that I have never received such hospitality as I have received in this beautiful island of Trinidad. Nor have the entertainments which have been organized for members of the Conference been wanting in teaching us what the Agricultural Society of Trinidad can show in the way of cacao growing, sugar growing, sugar manufacture, and cacao curing. We have all of us learnt a great deal; we have had the greatest pleasure in studying what they have shown us, and we have also had pleasure in visiting the various lovely and beautiful valleys which surround the capital of this island. I have seen Port-of-Spain before, but I had no idea that the island generally was of such extreme beauty. (Cheers.) I have seen some very grand scenery in the land of my birth, British Guiana, but I have never seen better scenery than I have seen here during the last week. At a meeting of the Entertainment Committee a gentleman said : 'Good-bye Mr. Tripp, what could we have done without you.' Long may he live and continue to be the Secretary of the Society which he adorns. (Applause.) We have specially to thank the Agricultural Society of Trinidad for the kind way in which they have arranged the various entertainments for us and the information they have afforded us. I now propose the 'Welfare of the Agricultural Society of Trinidad, and the health of the members of the Entertainment Committee,' coupling with the toast the name of Mr. Clifford. (Applause.)

The toast was drunk with enthusiasm.

The Hon. Hugh Clifford (Colonial Secretary) in responding said : Quite at the last moment I have been informed that it is my duty to reply to the toast of the Agricultural Society of Trinidad. As the least learned, the least agricultural, and, with the notable exception of Mr. Tripp, the least talkative member of the Agricultural Society (laughter), I feel that the selection might quite easily have been made a far more happy one; but at the same time I regard it as a great privilege conferred on me to reply, though very inadequately, to the kind things that Mr. Howell Jones has said of the Society. I need not tell you how great a pleasure and honour it has been to all of us in Trinidad to entertain the very distinguished company that has assembled in our island. It was my privilege the other day to be present in the Princes' Buildings when his Excellency the Governor made a contribution to the debate on the subject of cane-farming, and while I sat, an interested but obscure listener in the background, and while my eye wandered around what Mr. Alleyne has described as the thirty-nine articles, and while the forty stripes save one would be laid on the hapless back of Trinidad, for a moment I felt dreamy, and I went away

wondering whether, when the future historian comes to write the history of the West Indies, he would say that Sir Daniel Morris, like the great agriculturist that we know him to be, had planted a seed which eventually is to come to great growth in the West India Islands. Whether the Conference that I was looking at, which was attended by members from all the West India Islands, and which represented the best talent and the best agricultural knowledge of all those islands, was perhaps the foreshadowing of a greater Parliament which might possibly represent, and adequately represent, all the interests of these islands in one great federation. (Applause.) That, gentlemen, is probing too deep into the future, and we are dealing now with the present. I will detain you no longer : only I may say to you, on behalf of the Agricultural Society of Trinidad, that if any pleasure has been yours in visiting this island of ours, it is not by any means equal to the pleasure which it has given us all to welcome you in our midst. (Applause.)

The party then separated.

SUGAR INDUSTRY (CONCLUDED).

A special session of the Conference was held on Friday, January 13, at 9.30 a.m..for the consideration of certain subjects still on the Agenda. The PRESIDENT announced that with the permission of the members he desired to afford Mr. Henderson an opportunity of making a further statement with regard to cane farming at Trinidad. There was evidently some misapprehension in the public mind in connexion with the figures, prepared and handed in to the Conference by Mr. Abel, especially in relation to the average tonnage of canes per acre obtained by cane farmers on the Naparima estates, and it was desirable that the position in regard to those figures should be cleared up if possible.

The Hon. S. HENDERSON (Trinidad) referred to an article in a local newspaper criticising his remarks at a former session of the Conference in relation to cane farming. In taking part in the discussion on this subject on January 5, he had not said that 5 tons 15 cwt. of canes was the average production per acre over the whole island. He had shown that this was the average production on 1,753 acres in the one district of Naparima and Point-a-Piêrre ; and his object was to support his position that cane farming had not, in that district at all events, accomplished all that was at one time expected of it. He desired to impress upon the Conference the seriousness of the labour question in Trinidad. It was absurd to suppose that either Mr. Abel or himself wished to discourage cane farming ; on the contrary, they wished to strengthen it, if possible, by showing that, if the present system was to be continued, it must be largely improved, otherwise it would be ruinous to the cane farmers themselves.

Mr. ABEL (Trinidad) said: The figures presented by me refer to the number of acres held by the cane farmers, the greater part of which is in canes, but not necessarily the whole.

Professor CARMODY (Trinidad) also took part in the discussion.

The PRESIDENT pointed out that the figures given by Mr. Abel showed the acreage held by the cane farmers but not necessary that under cane. It was desirable that they should know the number of acres actually under cane; also whether a cane farmer could always keep the area held by him in canes every year.

In reply Mr. ABEL stated that under the present system this was not possible.

The discussion was continued by Dr. MORTON, Mr. ABEL, Mr. HENDERSON, Mr. HART, and Professor CARMODY (Trinidad), and Mr. HOWELL JONES (British Guiana). The PRESIDENT in closing stated that it had been shown that it would not be correct to assume that the number of acres held by the cane farmers was the acreage actually under canes. Unless the actual number of acres under canes each season was obtained, the average return in tons of canes per acre could not be ascertained. There was the further point to be borne in mind that the figures supplied by Mr. Abel had reference to about one-tenth of the total area held by cane farmers in the colony.

GENERAL SUBJECTS (CONTD.).

Mr. HOWELL JONES (British Guiana) opened the discussion on the subject of Rice Cultivation in the West Indies. He said that in British Guiana the industry was slowly but surely growing. The industry had increased to such an extent that in the district of Essequibo hundreds and thousands of acres could now be seen in rice cultivation. He dealt fully with the system of cultivation and the varieties grown. They had found that the 'hill' varieties grown in India without water had given better results than the so-called 'swamp' varieties. In 1903-4 there was a total of 16,669½ acres under rice cultivation, the yield being 17,701 tons of paddy, equal to 12,940 tons of rice.

Dr. MORTON (Trinidad) dealt with rice growing in Trinidad. In recent years the cultivation of Upland rice had declined considerably in Trinidad, but the cultivation of swamp rice had grown rapidly. The three favourite varieties of swamp rice were those known as 'Joyiya', 'Mutmuriya', and 'Jarahar'. Thirty barrels of the first, in the husk, might be taken as a good yield per acre, and 15 barrels of the Upland. He advocated assistance by drainage of lands that flood, by means of improved seed, and by devices for storing surplus water against a time of drought.

Mr. FAWCETT (Jamaica), Mr. MEADEN (Trinidad), Dr. WATTS, (Leeward Islands), Mr. HUDSON (St. Lucia), and Mr. BECKETT (British Guiana) entered into the discussion on this subject.

Mr. BALLOU (Entomologist on the staff of the Imperial Department of Agriculture) made a few remarks on several insect pests of rice which had come to his notice.

The PRESIDENT then announced that the papers on the following subjects would be taken as read :—

The Cocoa-nut industry at Trinidad. (Mr. W. GREIG.)

The Hairy or Woolless sheep of the West Indies. (Mr. W. R. BUTTENSHAW, M.A., B.Sc.)

The influence of the soil on the special qualities of Agricultural Produce. (Mr. J. H. HART, F.L.S.)

Are the special qualities possessed by individual plants sufficiently regarded? (Mr. J. H. HART, F.L.S.)

The PRESIDENT then invited members to bring forward special subjects on which they might desire an expression of opinion. Mr. G. SEBERT EVELYN (Barbados) referred to the bad condition of fruit imported into Barbados from Trinidad, British Guiana, and Grenada. This led to a general discussion on the subject of the import and export of fruit between the different islands, in which it was shown that the fruit seasons varied and this had led to a general exchange of fruit throughout the West Indies. One great cause of the bad condition of the fruit landed at Barbados was its conveyance in sailing vessels instead of in steamers.

EXCURSIONS.

Through the kindness of the Trinidad Agricultural Society three very interesting excursions were organized. These were the excursions on January 7, 10, and 12. By means of these excursions the Representatives were enabled to obtain a good idea of methods of cultivation adopted by Trinidad planters.

On January 4, a visit was made by the Representatives to the Botanic Gardens, and on the following day to the St. Clair Experiment Station when Mr. J. H. Hart, the Superintendent, kindly pointed out the objects of interest.

A visit was made to the Usine St. Madeleine on Saturday, January 7, the Representatives being shown over the factory by Mr. Peter Abel. After leaving the Usine the Representatives were taken to Princes' Town for lunch.

On Monday, January 9, an afternoon visit was paid to Mr. Hoadley's cacao estate at Chaguanas to inspect a new steam-drying plant for cacao, and also a factory for preparing concentrated lime juice and distilled oil.

On Tuesday, January 10, they left Port-of-Spain at 9 a.m. by special steamer for La Brea, to see the celebrated Pitch Lake.

The Annual Sale of Stock at the Government Farm taking place on Wednesday, January 11, a number of the Representatives took the opportunity of attending.

On Thursday, January 12, a visit was paid to the Caroni estate where the Naudet diffusion process plant was in course of being installed. Mr. W. G. Kay was kind enough to explain in detail the various parts of the diffusion battery and the advantages hoped to be attained from the new process as comparedi with the present system of roller crushing. An opportunity was also given of seeing the steam ploughs at work on this estate. The Representatives then proceeded to La Horqueta estate, the property of Messrs. Borde Bros., and inspected the cacao cultivation. Further opportunities of seeing cacao cultivations were obtained at Sangre Grande.

EXHIBITS.

Members of the Conference and others submitted a large number of interesting exhibits. A special feature of these was the large collection of samples, shown by Professor Carmody, illustrating the industries of Trinidad ; this included sugars, cacao, oils, and other vegetable products as well as a number of mineral products such as asphalt, oils, etc. There was also the series of samples of Sea Island cotton from Trinidad, St. Vincent, Barbados, and St. Kitt's. A special opportunity was given for members to inspect these samples and also to obtain information with respect to them from the various gentlemen who had brought the exhibits, especially with a view of affording information as to the quality of the samples of cotton.

In addition there were some interesting exhibits of sugar-canes brought by Mr. Bovell from Barbados. These included a number of curiosities, such as forked canes, canes which possessed no buds, known as 'male' canes, and several others. Mr. Bovell also exhibited samples of onions showing the character of onions grown in Barbados from Teneriffe seed.

In the outer hall were specimens of small ploughs such as were likely to be of service to small settlers and cane farmers.

CONCLUSION.

The President: I am glad that the business of the Conference is now drawing to a close, and that I shall soon be in a position to release you from further attendance. In doing so I have to express my great indebtedness to you for coming here and for the close and constant attention you have devoted to the subjects submitted for your consideration. We have had eight sittings of the Conference—five last week and three this week. In addition, we have devoted four afternoons for the purpose of visiting the Botanic Gardens, the St. Clair Experiment Station, Mr. Hoadley's cacao estats, and the Government Stock Farm. One afternoon (Friday) was spent in making

ourselves acquainted with the suburbs of Port-of-Spain by means of the electric tram. Three full-day excursions kindly organized by the Trinidad Agricultural Society, enabled us to visit (1) the St. Madeleine Sugar Factory and Princes' Town; (2) the Pitch Lake at La Brea, and (3) the Caroni Sugar Estate where the 'Naudet' process of sugar extraction is in course of being installed, and steam ploughing was being carried on; also in inspecting the fine Horqueta cacao estate (1,000 acres) belonging to Messrs. Borde Bros., and the newly opened district of Sangre Grande. We have thus combined work with a reasonable amount of relaxation and so kept in view the practical as well as the scientific side of agriculture. I regret that it was found impossible to take up the question of Praedial Larceny at this Conference. I am convinced, however, that sufficient time had not been allowed to obtain copies of the laws already in force and to bring together and tabulate for reference the large mass of information that has already been accumulated upon the subject. I suggest that between now and the next Conference the several Agricultural Boards and Agricultural Societies might obtain such information, and that a summary be prepared and printed beforehand. We could then hope to deal usefully with a matter requiring an intimate acquaintance with the social and economic conditions existing in the West Indies and offer suggestions that would be likely to commend themselves to the consideration of the several Legislative bodies with whom, and with the Governors, the final decision must be left. Returning to the business already dealt with, there can be no doubt as to the success of the present Conference. We have discussed fully, and I hope with good results, the numerous subjects intimately connected with the welfare of these colonies, and I trust you will return with renewed interest in the important work in which you are engaged, strengthened by the spirit of mutual support engendered by these gatherings and determined to do all that lies in your power to improve the agricultural interests of the West Indies. I may mention that it is proposed to publish the proceedings of this Conference in the *West Indian Bulletin*, and a special effort will be made to place valuable information that has been accumulated within the reach of the planting community as soon as possible. In the meantime, an extra number of the *Bulletin* containing the opening address of the Governor, the Presidential address, and an abstract of the proceedings will be issued at the close of the month. I trust that members of the Conference and others will avail themselves as fully as possible of the advantages offered by the *Agricultural News* (the fortnightly review of the Imperial Department of Agriculture) and bring forward, from time to time, subjects of general interest to be discussed in its columns. This would be a useful means of disseminating agricultural information of an interesting character bearing on the requirements of the West Indies. It only remains for me in conclusion to express in your behalf the cordial thanks of this Conference to the Government, the Agricultural Society, and the people of Trinidad for the cordial reception we have received at their hands and the excellent arrangements that

have been made not only for the business of the Conference but for the pleasant visits to sugar and cacao estates and other places of interest in the colony. (Applause.)

The Hon. B. HOWELL JONES (British Guiana): Mr. President, I have pleasure in proposing the following resolution as embodying the feelings of the members in reference to the cordial reception they have received in this island: 'The Members of the West Indian Agricultural Conference desire to express to his Excellency the President and Members of the Agricultural Society and the Planters of Trinidad their grateful thanks and appreciation for all their assistance, attention and courtesy to the Members of the Conference, and trust our united labours will bear fruit to the advantage of the agricultural interests of Trinidad, as we believe they will to the interest of the other colonies represented.' (Cheers.)

Mr. J. R. BOVELL (Barbados): It is with very much pleasure that I rise to second the Resolution which has just been moved by Mr. Howell Jones. I am sure that I express the feelings of the Members when I say that we are all exceedingly grateful to his Excellency the President and the members of the Trinidad Agricultural Society for the great kindness and courtesy they have shown us since our arrival in the colony. (Cheers.) The information and knowledge we have gained will be of the greatest value to the various colonies we have the honour to represent. (Cheers.)

Dr. FRANCIS WATTS (Leeward Islands): As completing the chain from the South, whence Mr. Howell Jones comes, to the North, whence I come, I should like to add a word, to express the gratitude and appreciation which every delegate of this Conference feels at the way in which we have been received in Trinidad. (Cheers.)

The Resolution was then put and carried unanimously.

The PRESIDENT: I shall have pleasure in forwarding a copy of the Resolution just passed to the Secretary of the Agricultural Society to be laid before the members at their next meeting.

The Hon. S. HENDERSON (Trinidad): I regret that, owing to illness, our respected Vice-President, Mr. Fenwick, is unable to be present to-day, for he would be more able than I am to express thanks for the kind things which the President has said and Mr. Howell Jones, Mr. Bovell, and Dr. Watts in connexion with the Resolution of thanks to the Trinidad Agricultural Society. I have to express to you, on behalf of the Society and my fellow representatives at this Conference, our very great appreciation of the good which this Conference, meeting here for the first time, will be to this colony, and the great gratification that your visit has afforded us. Every member of the Agricultural Society who has been present during the deliberations of this Conference has gained knowledge which must be of value to them in carrying on their agricultural affairs. Personally, it has surprised me to find how much valuable work has been done by the Imperial Department of Agriculture under the direction of our distinguished President. (Cheers.) All sugar planters in this colony have for

years been watching the progress of that Department, and we hope that some day Sir Daniel Morris will place in our hands a cane which will give far more valuable results than any existing cane. This Conference has shown that the goal is within reach. When reached, we shall owe another debt of gratitude to the Imperial Department of Agriculture. There is a further point on which I would touch. Beyond the agricultural value arising from this Conference, there is another of great importance and that is the bringing together of representative men from different parts of the West Indies and the creation of a bond of sympathy which must break down the insularity in which these islands have too long enveloped themselves. This has been a great barrier to the development of an Imperial idea in these colonies. I look forward to the time when such distinctive terms as Barbadian, Trinidadian, Jamaican, and others will all be merged in the one general term of West Indian. (Cheers.) Only when this spirit is imbued in us shall we occupy our true position among the colonies of the Empire. In conclusion, on behalf of the Trinidad Agricultural Society, and standing as we do on the threshold of a New Year, I heartily wish the delegates who are now about to leave us, and the officers of the Imperial Department of Agriculture, *bon voyage*, not only to their respective homes, but throughout the year 1905.

The Rev. Dr. MORTON (Trinidad): I have been asked to say an additional word because we do not think one man, however able he may be, can fully express how indebted we feel to the President and Members of this Conference for what we have been able to learn from them. There is, however, one matter to which we have not given sufficient attention, and that is the visits and excursions which we have had together and which, perhaps, have afforded us opportunity of knowing one another better than it was possible to know one another around this table. (Cheers.) As a member of the Reception Committee, it became my duty, as also my great pleasure, to accompany the members on some of the excursions, and I am sure I profited very largely from the conversations we had together. [Mr. J. R. BOVELL: So did we.] In that way we came to understand one another's defects and one another's good points. Of course, none of us are perfect, and when we see how others are striving in their own way it is a help, it creates sympathy between the various workers which must tend to do good in the end. There is only one other remark I wish to make. Some of us are getting old and cannot expect to attend many Conferences and do much in the future. You young men are offered exceptional opportunities of training; you are entering into the world of effort at an older and riper and more profitable stage than some of us. Be faithful to the mission entrusted to you; do your best as missionaries for agricultural science. That is a mission for men and a mission of God. (Cheers.)

Prof. P. CARMODY (Trinidad): The duty which I have to perform is an agreeable one, and although I know that the time of members is very valuable when the ship is waiting to take them away, still I feel I should not be doing my

subject justice and carrying out your wishes, unless I occupied your valuable time in proposing a vote of thanks to the President for the able manner in which he has presided over the Conference. (Cheers.) I will deal with it from two points of view, and condense my remarks as briefly as the importance of the subject will allow. In the first place, I thank you, as much, I may say, on behalf of members of the Conference, as of the colony itself, for having so arranged that this Conference should be held in Trinidad. (Cheers). I know that nothing has given you greater satisfaction than to bear testimony to the keen interest with which this Conference has been received in Trinidad, and I need not repeat to you that we have felt the honour of this island being chosen as the place for the Conference this year. As a result, we have endeavoured in every possible way to make the Conference a success. (Cheers.) It is not merely the officials of Trinidad nor the representatives of the Agricultural Society who have done their best, but every one in the colony whom we have asked to assist us have come forward most willingly and done all they could for the welfare of this Conference. (Cheers.) There is another point of view which I think is of great consequence. We know that the interchange of views between the different members of the Conference and between the planters and the commercial men outside has benefited all of us. But there is a much more important thing, and that is, the educative influence for years to come of this Conference upon the people of this colony. (Applause.) You will find that you have done an excellent thing in bringing the Conference to Trinidad, as a greater interest—that is, a more intensified and detailed interest—in agriculture than ever felt before in this colony will be the result. The number of papers dealt with at this Conference has been very large. They included a variety of subjects, and not only a variety of subjects, but a variety of treatment according to the special conditions and circumstances arising in each colony, and to deal with so large and exhaustive a series of papers required no small ability, no small tact, no small acquaintance with the circumstances of the West Indies. Mr. President, you have dealt with all the subjects at this Conference in such exhaustive detail, and you have shown such marked ability in conducting every feature of it, as to earn the admiration of every member of the Conference. You, Sir, have done a work in support of agricultural education and agricultural knowledge by means of these Conferences as will prove of lasting credit to you. (Applause.)

Mr. J. R. WILLIAMS (Jamaica): Mr. President, I feel it a great honour to be asked to second this Resolution. It must be very gratifying to you, Sir, to know the opinion that is formed of the work of the Imperial Department of Agriculture by the popular Agricultural Societies, who, without any control from you, have voluntarily banded themselves together to carry out on practical lines the work initiated by your Department. A few years ago these Societies did not exist, and now you will find that the popular opinion outside the societies is largely the same as inside, namely, that the whole future of the West

Indies depends on its agricultural improvement. (Cheers.) In a word, your Department has been the central force which has influenced us, and the Agricultural Societies have helped to influence public opinion and to secure the leavening of the whole lump. I believe I shall consult your wishes, as well as the inclination of this Conference, if I am very brief; but I ask you to accept our commendation and admiration of the results of the Conference over which you have presided. (Cheers.) In whatever degree any one of us is able to benefit the community in which he lives, we are all going away with that power considerably increased. (Applause.) Professor Carmody has mentioned the great educational benefit likely to arise to the community in which this Conference is held. I believe that it is a very important point, also, in relation to Jamaica, and I hope you will favourably consider Jamaica as the next meeting place of the West Indian Agricultural Conference. The other night his Excellency the Governor said the prosperity of the Imperial Department of Agriculture was secured so long as you continued to preside over it. I think that is a sentiment which everybody accepted with the fullest accord. (Applause.) I hope also your work will have the full approval of the authorities at home, so that we shall see the Department become a permanent establishment, and that, long after you are removed from its threshold, the work will continue an abiding monument of what you have done for the West Indies. (Great applause.)

The President: I am deeply touched by the kind manner in which you have been good enough to recognize my services as President of this Conference, and the appreciation that has been expressed in regard to the work of the Imperial Department of Agriculture. I value the expression of your opinion on those points, not only as affecting myself, but as evidence that the Department has attained an appreciable measure of success in carrying out the important mission entrusted to it. Also, that it is steadily and surely gaining the confidence and support of the mass of the people of these colonies I admit that during the last six years there have been occasions when a good many difficulties had to be overcome, and when not a little opposition fell to our lot from one or two quarters where we had hoped to receive sympathy and support. These, however, have not discouraged us, as we were convinced that, with a wider and more intimate knowledge of the aims and objects of the Department and the unwearied and unselfish devotion of those connected with it, our efforts would in the end be recognized. What has been mentioned by Mr. Williams, as to the voluntary efforts made by the Agricultural Societies to adopt and extend the methods of the Department, is a conclusive proof of the wide-reaching influence it is exerting throughout the West Indies.

The success of this Conference is a source of great satisfaction not only to myself but to those officers of the Department who have taken so active a part in it. I would especially refer to the services rendered by the Secretaries of the Conference (Messrs. Buttenshaw and Howell) who have

discharged the voluntary duties assumed by them to our entire satisfaction. (Applause.)

In the natural course of events, my connexion with the Department must come to an end, but, whenever that time arrives, I shall have the satisfaction of knowing that there will not be wanting able and experienced men to take my place. In the meantime, nothing will be wanting on my part to continue my efforts in behalf of the West Indies. (Applause.)

I now declare the Conference closed and thank you for your cordial assistance and your kind words of appreciation.

AGRICULTURAL CONFERENCE, 1905.

(CONTINUED).

In the previous pages a brief Abstract of the Proceedings has been given. It is now proposed to publish in full the principal papers, with a summary of the discussion upon each :—

RESULTS OF RECENT EXPERIMENTS WITH SEEDLING CANES AND MANURIAL EXPERIMENTS IN THE WEST INDIES.

BRITISH GUIANA.

The following paper on recent progress of sugar-cane experiments in British Guiana*, prepared by Professor J. B. HARRISON, C.M.G., M.A., F.I.C., F.G.S., was read by Mr. E. W. F. ENGLISH :—

BOARD OF AGRICULTURE EXPERIMENTS.

(a) *Older Varieties of Sugar-cane.*—Experiments with these have been practically discontinued. The results of fifteen years' continuous experiments showed that, taking the yield of the Bourbon variety as 100, the values of the better kinds were as follows :—

White Transparent	100
Mani	100
Po-a-ole	98·5
Red Ribbon	94·4
Tamarind	84·9
Bois-rouge	81·9
Chigaca	81·2
Kamba-Kamba-vati	80·9
Sacuri	80·0
Purple Transparent	79·4
Elephant	75·7

Few of these varieties are now to be found in the cane fields of this colony. About 1,800 acres are occupied by White Transparent canes, but this area will be largely reduced in the near future. Canes of this variety are also found sparingly scattered through the fields of Bourbon canes. A few acres are occupied by Red Ribbon and Purple Transparent canes grown for experimental purposes, while scattered canes of these varieties may be found in the fields of Bourbon, as a rule more sparingly than are White Transparent. Here and there, a few

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* This paper covers the period January 1, 1900, to December 31, 1904, and therefore contains the most recent information available.

canes of other varieties may be found, remnants of varieties distributed in the eighties.

None of these varieties on the large scale have equalled in productiveness the Bourbon variety, and every one of them has defects, either from the cultural or the manufacturing point of view, and frequently from both, which effectually prevents them from competing for the planters' favour with the Bourbon as 'all-round' canes. The following table shows the number of sugar-plantations in British Guiana on which the older varieties are being cultivated and the acreage occupied by them :—

	No. of Plantations.				Acreage.			
	1901-2.	1902-3.	1903-4.	1904-5.	1901-2.	1902-3.	1903-4.	1904-5.
Bourbon ...	52	51	51	50	67,732	66,194	65,608	59,238
White Transparent ...	24	27	30	28	1,889	2,786	2,876	1,796
Purple Transparent ...	3	2	1	nil	49	35	29	nil
Red Ribbon ...	nil	2	1	1	nil	24	6	5
Samsara ...	2	nil	nil	nil	8	nil	nil	nil
					69,678	69,039	68,519	61,039

Total area in sugar-cane.

1901-2	74,014 acres
1902-3	75,712 „
1903-4	78,468 „
1904-5	73,981 „

(b) *Newer Varieties raised from Seeds.*—As you are all aware our searches for new varieties by means of seminal reproduction and seedling selection are, speaking from the point of view of agricultural time, in their infancy. When the writer made his first visit to Trinidad in 1888, our first seedlings in Barbados were in a stage of very early infancy, and Mr. Bovell and myself hardly ventured to hint that we were guilty of a then scientific heresy; we were—although assured by the highest authorities that the sugar-cane never produced fertile seed—growing canes from fallen pieces of cane-arrows. Your Trinidad Botanist, Mr. Hart, assured me that he saw no reason for doubting that the sugar-cane could and did produce fertile seed, and I think that I am safe in stating that he was the first West Indian botanical authority to recognize our new departure and its probable importance.

In British Guiana since 1900 we have raised about one-third of a million tiny canes, and have selected some 26,000 of them for field experiments. Out of these we have selected a few hundreds for continued experiments, and from them the planters have selected a very few, certainly not more than fifty varieties, as being possibly of value to them as sugar producers. Out of that fifty some dozen or so show promise of being of actual value agriculturally as producers of sugar.

We have an area of about 35 acres only, available for our own experiments, and hence confine ourselves to preliminary small-scale experiments. Our system of selection is:—

first selection of parent varieties for seed producers;

second selection of the more vigorous of the seedlings obtained from them for field propagation;

third selection of the varieties growing under field conditions by the cultural characteristics;

fourth selection from these selected sorts by their analytical characters;

fifth selection. The third and fourth methods are repeated with plants raised from the tops of the varieties selected under the fourth selection, and this is done repeatedly during the cultivation of them from plants to second and third ratoons. As the method of cultivation in British Guiana renders it necessary for canes to have good ratooning powers to be of service as sugar producers, we lay more stress on the selection from ratoons than from plants;

sixth selection. These varieties, which have been selected are next grown on plots of about $\frac{1}{20}$ acre, side by side and under identical conditions of cultivation and manuring. On these their peculiarities are carefully watched, and out of batches of forty or so selected for this trial probably not more than a dozen will be retained in cultivation as third or fourth ratoons;

seventh selection. During the course of the fifth and sixth selections several of the varieties finally retained in cultivation will have been selected by planters by large-scale cultivation. These and a few others selected by ourselves are next examined by means of manurial experiments. Plots of about $\frac{1}{2}$ acre are divided into smaller plots, and upon these the varieties are raised under varying systems of manuring. Some of the plots of every kind are manured with phosphates, and perhaps potash, others are not. Some of each are grown without any nitrogenous manures, others with increasing quantities of nitrogen. It has been found that the mean results of a kind under the varying kinds of manuring apparently offer the most reliable figures as to comparative value we can obtain on small-scale experiments.

The following table shows the relative values up to fourth ratoons of the best of the varieties we have submitted to our sixth selection :—

No. of Variety.	Saccharose in expressed Juice per acre of Canes.	1900-4. Indicated Yields compared with Bourbon as 100.
	Tons.	
145	4·80	170·8
625	4·73	168·3
B. 147	4·68	166·5
115	4·54	160·1
109	4·38	155·9
1,087	4·00	142·3
2,468	3·99	142·0
3,157	3·82	135·8
1,896	3·72	132·3
1,640	3·50	124·6
135	3·48	123·8
754	3·15	112·1
White Transparent ...	3·02	107·5
1,483	3·00	106·7
Bourbon	2·81	100·0

The relative values, as compared with the Bourbon taken as 100, of the yield (in tons of canes per acre) of the canes now in course of the seventh selection on both new and old land are indicated as follows:—

	New Land.	Old Land.
D. 625	220·0	162·1
D. 145	157·0	182·8
D. 130	150·0	...
D. 115	141·5	145·7
D. 116	142·6	...
D. 109	130·6	149·3
D. 78	132·4	125·0
D. 3,956	130·0	...
D. 74	127·0	...
D. 95	117·6	...
White Transparent ...	91·5	120·0
Bourbon	100·0	100·0
B. 147	88·3	...
D. 2,190	58·2	...

The Bourbon does not flourish on this land, which is very heavy clay land, and hence the excess-yields of many of the other varieties are far higher than will be obtained on the commercial scale.

Until the year 1901 the late Government Botanist, Mr. G. S. Jenman, was in direct charge of the work of raising seedlings from seed. He planted seeds irrespective of their parentage and obtained a large number of new kinds. The following shows the results in recent years of this mode of sowing in the percentage of canes obtained which passed the fourth selection as either 1st., 2nd., or 3rd. class :—

	Planted in field.		Per cent. of seedling plants which passed.
1896	1,127		4·6
1897	63		9·5
1898	2,452		4·9
1899	2,807		·7
1900	7,760		1·3
Total ...	14,279	Average ...	2·1 per cent.

In 1901 and since I have caused a rigorous selection of the varieties from which seeds are to be taken to be made, and the following shows the results :—

	Planted in field.		Per cent. of seedling plants which passed.
1901	4,839		6·3
1902	3,764		1·7
1903	1,407		18·4
Total ...	10,010	Average ...	6·3 per cent.

Apparently our newer method is the more successful in producing what may be termed the raw material for our researches—new varieties of canes which have passed the 1st. cultural and been placed in classes 1 to 3 by the chemical selection.

EXPERIMENTS ON SUGAR ESTATES.

Practically almost every sugar estate in the colony has carried on small-scale experiments with varieties of canes, but as it had been long recognized in British Guiana that the results of small-scale experiments *and especially of small-scale experiments conducted on sugar estates where it is impossible to give the minute care and attention such experiments require and receive at the experiment station* are frequently unreliable in their indications for guidance in the selection of varieties for cultivation of the manufacturing scale, no notice is taken of their results except perhaps by the Manager of the estate. But we have established a system of large-scale experiments under which only results obtained on areas of not less than 1 acre and repeated on not less than six estates are recognized. These give more reliable results especially in cases where the area under cultivation is relatively large and the trials are numerous. The following table shows the results of these field trials between 1900 and 1905, giving the mean yields of commercial sugar reported as obtained

per acre by each variety during six crops and the proportion of the yield compared with those of the Bourbon and of the White Transparent taken, respectively, as 100.

	Tons of commercial Sugar per acre.	Bourbon = 100.	White Transparent = 100.
D. 625	2·50	135·8	150·6
D. 95	2·02	109·7	121·6
Sealy	1·96	106·1	118·0
D. 145	1·95	105·9	117·4
D. 109	1·93	104·3	116·2
B. 147	1·86	101·6	112·0
Bourbon	1·84	100·0	110·8
D. 74	1·72	93·5	103·6
White Transparent ...	1·66	90·2	100·0
D. 78	1·49	80·9	89·9

Certain estates have not found it feasible to give returns of the yield of each variety but have supplied comparative returns of the yields of the Bourbon and of seedling varieties. The following are examples of this :—

	Bourbon.			Seedlings.		
	Acreage.	Total Yield.	Tons of commercial Sugar per acre.	Acreage.	Total Yield.	Tons of commercial Sugar per acre.
Estate No. 1 (*a*)	703	1,588	2·26	151	384	2·55
(*b*)	684	1,977	2·89	146	431	2·94
Estate No. 2 (*a*)	1,578	3,263	2·07	881	2,340	2·65
(*b*)	1,120	2,800	2·50	1,001	3,180	3·18
Estate No. 3 (*a*)	1,494	2,347	1·57	793	1,448	1·82
(*b*)	956	1.280	1·30	1,003	1,711	1·70

This is an average increase of ·35 tons of sugar per acre or of 17 per cent. in favour of the seedling varieties.

The field and factory results obtained in the large-scale experiments are of high value, as, apart from the actual yields per acre of canes and of commercial sugars, the various difficulties which arise with the new varieties especially in crushing and in the value of their megass for fuel purposes are recorded. During the earlier periods of the large-scale experiments it appeared that these difficulties might have proved sufficiently formidable in practice to prevent the adoption of new varieties on the commercial scale, but now they have been largely overcome, and probably in the course of time our planters will succeed either in eliminating them or in obtaining new varieties of canes in which these defects do not occur.

During the crop of September-December 1904 the areas occupied by the principal varieties reported upon in the large-scale experiments were: D. 625, 174 acres; D. 95, 74 acres; Sealy, 41 acres; D. 145, 105 acres; D. 109, 882 acres; B. 147, 355 acres; Bourbon, 11,900 acres; and White Transparent, 1,725 acres.

I estimate that at present an area of about 14,800 acres is occupied in British Guiana with varieties other than the Bourbon, and of these about 13,000 acres are cultivated in new seedling varieties.

The favourite varieties with our planters are D. 109, B. 147, D. 145, D. 625, and B. 208.

The following tables show the number of plantations raising seedling canes on the large scale, and the areas occupied on them by the various varieties during recent years, and will illustrate the gradually increasing favour in which certain of the new kinds are held:—

NUMBER OF PLANTATIONS.

Cane.	1901-2.	1902-3.	1903-4.	1904-5.
D. 109	20	26	32	33
D. 78	15	21	20	11
B. 147	19	20	22	21
D. 145	14	19	28	27
D. 95	9	11	11	10
D. 74	10	14	12	11
D. 625	11	16	24	28
D. 115	8	10	12	11
B. 208	1	2	6	8
B. 109	3	4	8	7
Sealy	8	6	14	12
D. 116	4	10	7	7
D. 117	1	6	6	3
D. 130	3	3	5	4
B. 156	1	5		2
Green Transparent... ...	3	3	3	2
B. 41	2	3	4	6
B. 386		4	2	1
D. 1,897		2	2	
D. 4,191		1	1	1
Burke	1	1	1	1
D. 1,087		1	2	2
D. 1,959		1	1	2
D. 4,415		1		
D. 2,468		1	4	3
Mixed and not enumerated varieties	33	42	41*	38*

* Amalgamation of estates.

ACREAGE.

Cane.	1901-2.	1902-3.	1903-4.	1904-5.
D. 109	1,727	2,583	3,941	5,491
D. 78	629	846	476	277
B. 147	599	789	1,151	1,329
D. 145	442	644	902	1,316
D. 95	335	316	416	231
D. 74	216	225	262	157
D. 625	79	191	542	1,445
D. 115	72	84	80	58
B. 208	43	151	713	1,437
B. 109	41	66	70	91
Sealy	40	93	177	221
D. 116	36	58	80	150
D. 117	9	17	111	21
D. 130	8	38	41	20
B. 166	6	10		
Green Transparent	5	20	31	54
B. 41	4	8	38	36
B. 386	10	51	55	25
D. 1,897		32	37	
D. 4,191		30	34	22
Burke	28	28	28	24
D. 1,087		10	13	11
D. 1,959		9	9	10
D. 4,415		5	15	5
D. 2,468		5	13	11
Mixed and not enumerated varieties		364	714	500
	4,329	6,321	9,285	12,942

Our experience, as far as it goes, indicates that in the selection of seedling varieties more attention should be given to the size of the cane, the number of shoots each stool produces, and to its ratooning power, which is, in the majority of canes, dependent upon its resistant power to disease and to drought, than to its high saccharine contents. We have found that while the tendency is for decrease in the course of culti-

vation in the first-named qualities, the sugar contents, in many instances, tend in an opposite direction.

Our experiments with quickly maturing, relatively small-sized canes, such as Nos. 74 and 95, with high saccharine contents have not been altogether satisfactory. A medium to large-sized cane with well-marked tillering and ratooning powers, and of fairly high saccharine content, say, equal to that of the Bourbon, appears to be of higher value to us in British Guiana, than are smaller, relatively rich varieties.

Fortunately, we have indications that among our latest selection of seedlings are large-sized varieties of very high saccharine contents.

Perhaps the advantage of the seedling varieties which is most appreciated by the planters is that several kinds are capable of yielding large and remunerative crops of canes on land on which the Bourbon will not now thrive. Some varieties will flourish on the heavy clay front lands of the plantations, others on the somewhat lighter soils at the back of the cultivations. On some estates the result of this is that the cane cultivation using seedling varieties is being extended at the back of the estates on soils that the Bourbon cannot flourish upon, while land set free from cane cultivation on the front lands is being planted in rice.

MANURIAL EXPERIMENTS.

Systematic manurial experiments have been carried on in British Guiana for the past twenty-four years, and much information has gradually accrued.

During the eighties many experiments were carried on on sugar estates in a manner closely resembling that at present in use in Barbados, Antigua, and St. Kitt's. Under conditions existent in British Guiana, it was recognized early in the nineties that these small-plot estate manurial experiments did not give authoritative results, being subject to the same disabilities as are all small-plot experiments on sugar estates.

The land devoted to sugar-cane in British Guiana is of fairly uniform nature and consists of sea-borne clay and sand in varying proportions. In places this alluvial soil is covered by more or less deep layers of a vegetable or peaty soil known locally as 'pegass.' From the uniform mode of origin of the soils it follows that, subject to modifications due to the various proportions of clay and sand present and to climatic conditions, results obtained on a station under well-planned arrangements should be applicable throughout the sugar-cane belt of the colony. Hence it is not considered desirable to multiply in the colony manurial experiment stations, but to leave it to every manager to use his skilled agricultural knowledge in making the modifications from the methods found advisable on the station on his estate and on the fields under his charge which his experience shows to be desirable to meet their varying conditions of soils, etc.

In 1890 part of the land now occupied by the Board of Agriculture's experimental fields was put under tillage, and

experiments with manures were commenced in 1891. The experiments were arranged according to a plan which I had prepared, and which had been submitted to the 'Masters,' Sir John Bennet Lawes and Sir Joseph Gilbert, of Rothamsted, for criticism and suggestions. They approved of it without alteration. This plan has been closely adhered to since.

At the commencement of the work we kept two objects in view: first, the determination of the effects of the manurial constituents of plant-food upon the yield of the sugar-cane; second, the determination, if feasible, of the effect of tillage, manuring, and cropping on the proportion of the readily assimilable manurial constituents of plant food in the soil. The results of the last few years show how far we have succeeded.

Lime.—Upon heavy clay land the action of lime in accentuating its fertility is frequently most marked. We treated every alternate bed in the field with slacked lime obtained from Barbados in the proportion of 5 tons per acre and costing for its purchase and application $30.

The excess-yields upon limed plots have been as follows:—

Crop reaped in	Tons of Cane per acre.	
	Not-manured plots.	Manured plots.
1892 Plants	6·4	7·05
1893 Ratoons	8·15	7·4
1894 ,, ...	3·2	3·45
1895 ,, ...	3·6	2·40
1896 Fallow	...	...
1897 Plants	4·3	5·4
1898 Ratoons	3·7	4·1
1899 ,, ...	Crop failed*	Crop failed*
1900 Fallow	...	...
1901 Plants	2·5	2·7
1902 Ratoons	·6	1·2
1903 ,, ...	·6	1·4
1904 ,, ...	·6	1·9
Total increase in 10 crops	33·7	37·0

* 1899 crop failed from drought.

Thus in the ten crops, the results of which are recorded, the lime has on land not manured produced an increase of 33 tons of canes, and on manured land one of 37 tons. Or, in round figures, 5 tons of lime have produced 3 tons of commercial sugar.

Phosphates.—Phosphates have as a rule exerted some effects. With superphosphates these have been most marked when the manure was applied to plant canes; little, if any, beneficial results having followed its application to ratoons. The applications have not, therefore, been invariably followed by financially profitable increases of produce. The experiments have indicated that the mode of application of superphosphate to the sugar-cane on the clay soils of Demerara most likely to prove profitable is to apply it in fairly heavy dressings, say, up to 3 cwt. per acre, to the plant canes, and to trust to obtain the benefit of the phosphates not utilized by that crop during the successive crops of ratoons. Comparative experiments made by applying superphosphates and slag-phosphates showed that heavy applications of slag-phosphates, say, of 5 to 6 cwt. per acre, to plant canes, have been more remunerative than dressings of superphosphates of equal cost, either when applied in heavy dressings to the plant canes or in lighter ones to successive crops of plant and ratoon canes.

Our present system is to apply slag-phosphates at the rate of 600 ℔. per acre to the young plant canes, repeating the application each successive series of plants and ratoons. It is a point requiring investigation as to whether it is necessary to apply slag-phosphates in our system of agriculture as frequently as once in every five years. We have some indications that it may not always be necessary to do so.

Potash.—We have experimented with the use of sulphate and of nitrate of potash as constituents of cane manures and have obtained results with both of them indicating that, on our heavy clay soils and under our system of agriculture, potash is not required as a manure for the sugar-cane under the usual conditions of agricultural practice.

Nitrogen.—(*a*) Bourbon variety.—Experiments have been carried on to ascertain the effects of nitrogenous manures upon the Bourbon cane, the White Transparent cane, Nos. D. 74, D. 78, D. 95, D. 109, D. 115, D. 116, D. 130, B. 147, D. 625, D. 2,190, and D. 3,956.

The results with the Bourbon show that between 1892 and 1902 the average increased yields over unmanured crops where the plots received applications, without phosphates and potash, of sulphate of ammonia and of nitrate of soda, supplying 40 ℔. of nitrogen per acre, were 39·8 and 33 per cent. respectively, the average increase in canes due to the sulphate of ammonia being 6 tons, and to nitrate of soda, 5·6 tons.

Experiments have also been made by applying sulphate of ammonia without mineral manures in higher proportions, but only over four crops with the Bourbon cane, the indications being that using quantities of sulphate of ammonia up to

300 ℔. per acre, the addition of phosphates and potash was not necessary to ensure their satisfactory manurial effects.

As a rule, the plots manured with phosphates and potash have given higher returns than those not so manured, the increase being 5·9 per cent. or 1·3 tons of canes per acre. It is noteworthy that the increased yields were highest during the earlier years of the experiments, and that during the last few years the tendency has been for the crops on the land which has received the purely mineral manuring to be less than those on the unmanured land.

Plots that have been manured with phosphates and potash have also been manured with sulphate of ammonia and with nitrate of soda in increasing proportions. The following shows the increase in tons per acre due to the nitrogenous applications and the percentage increases as compared with the plots without nitrogen taken as 100 :—

Nitrogen per acre.	Sulphate of Ammonia.		Nitrate of Soda.	
	Tons of canes.	Per cent. increase.	Tons of canes.	Per cent. increase.
40 ℔.	5·2	32 6	5·6	37·2
60 ℔.	7·6	47·6	7·0	46·5
80 ℔.	9·6	60·2	7·3	48·4

These results obtained over ten crops in thirteen years indicate that 10 ℔. of nitrogen in the form of sulphate of ammonia, when added in proportions up to 300 ℔. per acre, give approximately 1·3 tons of canes or, say, at 9 per cent. recovery, $2\frac{1}{3}$ cwt. of commercial (96 per cent.) sugar. It is an easy matter to estimate, knowing the prices of sulphate of ammonia and of sugar respectively, if manurings on land in good heart with sulphate of ammonia are likely or not to prove profitable. Similarly, as higher applications than 300 ℔. of sulphate of ammonia will probably result in 1 ton of canes or 1·8 cwt. of commercial sugar for each 10 ℔. of nitrogen applied, the advisability of higher manurings than 300 ℔. can readily be determined.

Similarly with nitrate of soda. Up to 250 ℔. of nitrate of soda, each 10 ℔. of nitrogen will probably give 1·4 tons of canes or $2\frac{1}{2}$ cwt. of commercial (96 per cent.) sugar. But it is evident from the figures that it is not wise to apply more than 250 ℔. of nitrate of soda per acre at one dressing.

Experiments have also been made in which dried blood has been the source of nitrogen, and the indications were, over a period of eight crops, that the relative value of the nitrogen in dried blood for use with sugar-canes was, in round figures, 73 per cent. of that of the nitrogen in sulphate of ammonia.

The effects of mixtures of nitrate of soda and of sulphate of ammonia used in place of sulphate of ammonia have been determined experimentally, but the results have not been more satisfactory than the use of either sulphate of ammonia or of nitrate of soda alone. Possibly, where heavier manurings than about 60 lb. of nitrogen per acre are used, the mixture may prove advantageous, but I have not tried it.

During two seasons, when the yields were adversely affected by drought and fungoid disease, comparisons were undertaken of the manurial value of nitrogen in raw guano, in sulphate of ammonia, and in nitrate of soda. The more readily available forms of nitrogen gave the better results.

(*b*) Seedling Varieties.—D. 145.—Experiments were commenced with this promising seedling variety in 1900 and the results may be summarized as follows :—

	Tons of canes per acre per crop.	
No Manure	17·0	
Farm manure 20 tons in 1900 ...	19·1	
Nitrate of soda 40 lb. nitrogen	26·2	Mean 23·7 tons.
Sulphate of ammonia 40 lb. ,,	25·8	
,, ,, 60 lb. ,,	20·4	
,, ,, 80 lb. ,,	22·5	
Phosphates and potash	22·0	
Phosphates, potash, and		
Sulphate of ammonia 40 lb. nitrogen	24·5	Mean 29·7 tons.
,, ,, 60 ,, ,,	30·5	
,, ,, 80 ,, ,,	34·1	
Phosphates, potash, and		
Nitrate of soda 40 lb. nitrogen	26·3	Mean 27·8 tons.
,, ,, 60 ,, ,,	25·7	
,, ,, 80 ,, ,,	31·3	

Another series laid down in 1901 on new land has given the following :—

	Tons of canes per acre per crop.	
No nitrogen	40·0	
10 lb. nitrogen as sulphate of ammonia	43·1	Mean 47·0 tons.
40 ,, ,, ,, ,,	50·6	
60 ,, ,, ,, ,,	44·9	
80 ,, ,, ,, ,,	49·3	

These results indicate that on the older long-cultivated land D. 145 required manurings with phosphates and potash to enable nitrogen in quantities beyond 40 lb. per acre to exert its full effect, and that when applied in the quantity supplied by 400 lb. of sulphate of ammonia per acre, each 10 lb. of nitrogen produced 1·5 tons of canes or, say, $2\frac{2}{3}$ cwt. of commercial (96 per cent.) sugar.

Nitrate of soda when applied in quantities of less than 250 lb. per acre was more efficacious than were equivalent amounts of sulphate of ammonia, but with higher dressings the reverse was the result.

Apparently D. 145 requires a larger proportion of available phosphates and potash for its full development than does the Bourbon.

On the new land D. 145 appears to have been able largely to utilize the stores of soil nitrogen, but, although the results of the manurings with nitrogen are not at all regular, it is evident that it has utilized applications of sulphate of ammonia to some extent. An average application of 50 ℔. of nitrogen as sulphate of ammonia has given 5·3 tons of canes, that is, an application of 10 ℔. of nitrogen has resulted in 1·06 tons of canes or in 1·9 cwt. of commercial (96 per cent.) sugar per acre.

D. 78.—A cane originally of very high promise but which has fallen off in vigour and productiveness for several years past.

The results with it may be summarized as follows :—

	Tons of canes per acre per crop.	
No manure	13·5	
Stable manure 20 tons in 1900 ...	17·1	
Nitrate of soda 40 ℔. nitrogen ...	20·0	
Sulphate of ammonia 40 ℔. nitrogen	18·9	Mean 23·2 tons.
,, ,, 60 ,, ,,	26·5	
,, ,, 80 ,, ,,	27·6	
Phosphates and potash	14·6	
Phosphates, potash, and		
Sulphate of ammonia 40 ℔. nitrogen	19·2	Mean 17·7 tons.
,, ,, 60 ,, ,,	16·6	
,, ,, 80 ,, ,,	17·2	
Phosphates, potash, and		
Nitrate of soda 40 ℔. nitrogen	17·4	Mean 19·5 tons.
,, ,, 60 ,, ,, ...	19·6	
,, ,, 80 ,, ,, ...	21·4	

The series laid down in 1901 on new land has given the following :—

	Tons of canes per acre per crop.	
No nitrogen	30·6	
20 ℔. nitrogen as sulphate of ammonia	35·1	Mean 41·6 tons.
40 ,, ,, ,, ,, ...	43·4	
60 ,, ,, ,, ,, ...	40·0	
80 ,, ,, ,, ,, ...	48·1	

On the old land the only deduction that can be drawn is that the yields of D. 78 have been increased by manurings with nitrogen, and this is accentuated by the results obtained on the new land. The very irregular nature of the records is due to the highly unsatisfactory mode of growth of this variety, a defect that has compelled us to cease its cultivation.

D. 625.—Two series of manurial experiments are being carried on with this important variety, the earlier on new land planted in 1901, the latter on longer cultivated land planted in 1902. The results are summarized in the following :—

	Tons of canes per acre per crop.	
No nitrogen	38·0	
20 ℔. nitrogen as sulphate of ammonia...	42·6	Mean 44·6 tons.
40 ,, ,, ,, ,, ...	42·7	
60 ,, ,, ,, ,, ...	45·5	
80 ,, ,, ,, ,, ...	47·6	

Here again we have an example of a variety that has marked powers of utilizing soil nitrogen.

D. 109.—This is the most widely planted seedling variety in British Guiana; like D. 625, it has been experimented on both in the new and the old land with the following results:—

	Tons of canes per acre per crop.	
No nitrogen	29·8	
20 ℔. nitrogen as sulphate of ammonia...	32·5	Mean 36·2 tons.
40 ,, ,, ,, ,, ..	34·7	
60 ,, ,, ,, ,, ...	38·9	
80 ,, ,, ,, ,, ...	38·7	

Another variety with marked powers of utilizing soil nitrogen.

D. 116.—This kind has been grown only on the new land. The following are its indications:—

	Tons of canes per acre per crop.	
No nitrogen	40·4	
20 ℔. nitrogen as sulphate of ammonia...	46·0	Mean 48·4 tons.
40 ,, ,, ,, ,, ...	45·0	
60 ,, ,, ,, ,, ...	53 6	
80 ,, ,, ,, ,, ...	49·1	

The demand of this cane for nitrogenous manures and its power of utilizing them appear to be similar to that of the Bourbon.

D. 3,956.—This has been experimented with only in the new land. Its results are as follows:—

	Tons of canes per acre per crop.	
No nitrogen	37·6	
20 ℔. nitrogen as sulphate of ammonia...	35·2	Mean 41·4 tons.
40 ,, ,, ,, ,, ...	37·9	
60 ,, ,, ,, ,, ...	43·8	
80 ,, ,, ,, ,, ...	47·4	

When the manurial experiments with varieties were started, it was thought that the following four varieties were not likely to be of commercial importance as sources of sugar in this colony, and nitrogenous manures were applied to them only in low dressings:—

D. 74.—Only grown on the new land where it has given the following results:—

	Tons of canes per acre per crop.
No nitrogen	30·2
20 ℔. nitrogen as sulphate of ammonia ...	37·2
40 " " " "	40·1

D. 95.—Grown similarly to D. 74.

No nitrogen	32·0
20 ℔. nitrogen as sulphate of ammonia... ...	33·0
40 " " " "	34·9

D. 130.—Also as D. 74.

No nitrogen	36·9
20 ℔. nitrogen as sulphate of ammonia... ...	42·8
40 " " " "	47·5

These rapidly maturing varieties show, with the exception of D. 95, a marked demand for manurial nitrogen and great powers of utilizing it to advantage.

D. 115.—This variety has been grown experimentally on both the new and the old land, and has given the following results:—

	Tons of canes per acre per crop.
No nitrogen	28·6
20 ℔. nitrogen as sulphate of ammonia .	33·5
40 " " " "	36·4

and apparently its nitrogen requirements are very similar to those of D. 74 and D. 130.

Experiments on the new land are also being carried on with D. 2,190 and B. 147, and with Bourbon and White Transparent for purposes of comparison. Only two crops of these have been reaped with the following results:—

	Bourbon.		White Transparent.	
No nitrogen	24·5		23·5	
40 ℔. nitrogen as sulphate of ammonia	29·0	Mean 31·3 tons	29·1	Mean 30·9 tons
60 " " " "	27·5		30·8	
80 " " " "	36·3		32·7	
	B. 147.		**D. 2,190.**	
No nitrogen	23·5		17·9	
40 ℔. nitrogen as sulphate of ammonia	26·7	Mean 29·7 tons	18·5	Mean 25·3 tons
60 " " " "	28·2		26·9	
80 " " " "	34·3		30·5	

These experiments supply us with ample proofs that every one of our new varieties requires manuring with nitrogen to give really satisfactory results. They indicate also that some of the varieties have higher powers of utilizing soil nitrogen than the Bourbon has, and that, while certain of them appear not to utilize manuring with nitrogen to as great advantage as does the Bourbon, others, on the contrary, may utilize it to greater advantage.

EFFECTS OF MANURES ON THE COMPOSITION OF THE SOIL.

At the commencement of the experiments in 1891 the soil of the field was most carefully sampled and an analysis made. The sample was preserved so as to enable future reference to it if desirable.

At the termination of the series of experiments in 1902, samples were drawn with the utmost care from the plots which had been variously manured. The proportions of total nitrogen, and of phosphoric anhydride and potash soluble in 1-per cent. aqueous citric acid solution, during five hours constant shaking in a mechanical (Wagner's rotating) shaker, were determined in these samples and in the original one. The analytical figures obtained have enabled us to form the following conclusions :—

(1) That the growth of the sugar-cane without nitrogenous manure is accompanied by a considerable loss of the nitrogen in the soil, amounting in ten years to 18·6 per cent. on not-limed land and to 26·7 per cent. on limed land. These are equivalent to losses from the soil to a depth of 8 inches of 880 ℔. and 1,250 ℔., respectively, per acre.

(2) Repeated heavy dressings with farmyard manure have resulted in an increase in the total nitrogen of the soil. In ten years the increase was 20·3 per cent., equal to 960 ℔. of nitrogen per acre added to the soil to a depth of 8 inches.

(3) The growth of the sugar-cane on plots receiving only nitrogenous manures has resulted in losses of soil nitrogen ; where sulphate of ammonia was applied, the loss amounted to 14·7 per cent. or to 670 ℔. of nitrogen, and where nitrate of soda was used, to 16·3 per cent. or to 775 ℔. of nitrogen per acre in the soil to a depth of 8 inches.

(4) On soils manured with phosphates, potash, and nitrogen in the form of sulphate of ammonia, the loss of soil nitrogen in the top 8 inches amounted to 14·7 per cent. or to 700 ℔. per acre, while where nitrate of soda was the source of nitrogen the loss was far higher, amounting to 26·5 per cent. or to 1,250 ℔. per acre.

The above show that the nitrogen which accumulates in the upper layers of the soil during long periods of forest growth or of fallowing, while the land is covered by dense growths of sedges, grasses, and leguminous plants, suffers great and rapid losses when the soil is put under intensive sugar-cane cultivation, and it is to the loss of the accumulated stores of readily available nitrogen that the marked falling off in the yield of canes per acre, which is almost invariably noticed when successive crops are taken off from either new or from long-rested soils, is due. This loss is greatly diminished where heavy dressings of farmyard or pen manure are regularly used, and upon very heavy clay soils the loss may be reduced to a minimum and an actual gain ensue.

The loss of nitrogen is greater on soils manured with nitrate of soda than on soils manured with sulphate of ammonia, and this may be due to the well-known action of the former salt in loosening and rendering the ground more permeable and hence more liable to losses by drainage.

The loss of nitrogen, as would be expected, is greater on limed soils than on not-limed ones.

(5) The soil in 1891, at the commencement of the experiments, yielded ·0142 per cent. of phosphoric anhydride to a 1-per cent. aqueous solution of citric acid. After ten years' cropping without manure it yielded ·0086 per cent., which shows a loss of nearly 40 per cent. of the probably available phosphoric anhydride or of, in round figures, 170 ℔. per acre.

(6) Where the soil received manures not containing phosphates, the proportion of probably available phosphoric anhydride was reduced to ·0096 per cent., equal to a loss of 32·4 per cent. or to one of, in round figures, 140 ℔. per acre.

(7) Where superphosphates were used in addition to nitrogenous manures the proportion of the probably available phosphoric anhydride was reduced to ·0132 per cent., indicating a loss of 7 per cent. or of 30 ℔. per acre.

(8) Where slag-phosphates had been applied, the probably available phosphoric anhydride has been reduced to ·0102 per cent. equal to a loss of 28·1 per cent. or to one of 120 ℔. per acre. It is worthy of note that in our more recent experiments, while manuring with slag-phosphates produced, on the plots which had received superphosphates during the earlier years of the experiments, mean increases of only 2·3 per cent., they produced, on those which had been manured with slag-phosphates, a mean increase of 5·8 per cent.

(9) The determinations of potash soluble in 1-per cent. citric acid solution and in 200th. normal hydrochloric acid showed that cultural operations have made probably available more potash each year than is required for the growth of the sugar-cane, the original samples yielding potash at the rates of 262 ℔. and 278 ℔. per acre to a depth of 8 inches, those not manured with potash salts during ten years at the rates of 376 ℔. and 500 ℔., and those which received potash salts in addition to nitrogenous manures at the rates of 357 ℔. and 530 ℔.

(10) Judging from the solubility of the lime in the soil in 200th. normal hydrochloric acid, cultural operations set free in a soluble form more lime than the crops utilized, the original soil yielding lime to the solvent at the rate of, in round figures, 3,400 ℔. per acre to a depth of 8 inches, while the samples taken after ten years' cultivation yielded at the mean rate of 3,800 ℔. The soils which received in July 1891 slacked lime, supplying, in round figures, 6,700 ℔. of actual lime per acre, yielded to the acid in 1902 a mean of 5,000 ℔. per acre, thus indicating after ten years' cultural operations a retention in the uppermost layer of the soil of only 1,200 ℔. of the added lime in a readily soluble form.

(11) The action of the lime on the solubility of the potash in the uppermost layer of the soil appeared well-marked, the samples from the not-limed land yielding to 200th. normal hydrochloric acid at a mean rate of 460 ℔. of potash per acre to a depth of 8 inches, while those from the limed land yielded at a mean rate of 640 ℔.

It has always been a matter of great difficulty to form an opinion from the analytical examination of a sugar-cane soil as to the desirability or not of manuring it with potash, phosphates, or lime. We cannot, even now, definitely state more than that such manurings on a soil containing more than a certain minimum (not yet accurately known) of these constituents will not result in increased yields, but the experiments which have been carried on in the experimental fields and the numerous analyses which have been made of our sugar-cane soils have enabled us to come to the conclusion that a British Guiana sugar-cane soil containing more than ·007 per cent. of phosphoric anhydride soluble in 1-per cent. citric acid solution by five hours' continuous shaking will not, as a rule, respond to manurings with phosphates, and that it is doubtful if soils yielding, under similar conditions, from ·005 to ·007 per cent. of phosphoric anhydride, will, as a rule, benefit by phosphatic manurings. If the soil yields less than ·005 per cent. of phosphoric anhydride, it is advisable to apply heavy dressings of slag-phosphates, or lighter ones of superphosphates, or of so-called basic superphosphates.

British Guiana soils, yielding ·008 per cent. of potash to the citric acid solution, can be regarded as containing, under the usual system of cultivation, sufficient available potash for the needs of the sugar-cane. If the soil yields from ·005 to ·008, it is doubtful if the application of potash salts will result in remunerative returns, and where the yield falls below ·005 it is advisable to add potash salts in the manures.

The demand of the sugar-cane for lime as a plant-food is low, and if the soil gives up more than ·006 per cent. to the 1-per cent. citric acid, it probably will yield sufficient for plant food for ordinary crops of sugar-cane.

The following are the general deductions arrived at during these experiments:—

(1) Nitrogen in the form of sulphate of ammonia, of nitrate of soda, or raw guano, and of dried blood exerted a favourable influence upon the yield of the sugar-cane, and is without doubt the manurial constituent the supply of which mainly governs the yield of the plant.

(2) When used in quantities capable of supplying not more than 40 ℔. of nitrogen per acre, there was practically no difference in the effects of sulphate of ammonia and of nitrate of soda, but, on the whole, the former is, in my opinion, the preferable salt to apply.

(3) Where applied in quantities supplying more than 40 ℔. of nitrogen per acre, sulphate of ammonia is the best source of nitrogen for the sugar-cane on the alluvial soils of British Guiana.

(4) The sugar-cane made more effectual use of the nitrogen supplied by 200 ℔. per acre of sulphate of ammonia and by 250 ℔. of nitrate of soda than it did of that supplied in heavier dressings. On the whole, dressings of from 2 to 3 cwt. of sulphate of ammonia per acre appear to be the most certainly

profitable applications of nitrogen, although in favourable seasons the use of higher proportions has proved successful.

(5) The application of superphosphate of lime to plant canes may give increased yields when added to manurings of nitrogen and potash. But little, if any, advantage has been gained by the use of phosphates with ratoon crops, and I am of opinion that manurings with superphosphate of lime or with other manures containing phosphates should be restricted to plant canes, the ratoons being manured with nitrogen only.

(6) As far as the experiments indicate, Thomas-phosphate-powder (slag-phosphate) is the preferable source of phosphoric acid for application to plant canes in lieu of superphosphate of lime. But the use of basic superphosphate appears to be of much promise.

(7) The use of lime has resulted in largely increased yields. Whether or not it results in profitable increases depends on the price of sugar. Its action appears to have been principally mechanical in improving the texture of the land, and it is a question of much importance whether this effect could not be obtained at a lower cost, and hence more profitably, by the use of light ploughs or other cultivators. Up to the present, experiments in this direction made on sugar plantations in British Guiana have not been quite satisfactory.

(8) The results confirm those of previous experiments that neither the addition of phosphoric acid, of potash, or of lime to the manures affects the sugar contents of the juice of the canes. The effects of nitrogenous manurings appear to be somewhat to retard the maturation of the canes, and thus the juice of canes manured with them is, as a rule, not quite so rich in saccharose as is that of canes grown without manure. But this effect is far more than offset by the larger yields of produce resulting from the application of nitrogenous manures and to the fact that the increases produced by the nitrogen are principally due to the development of the stalk in length and in bulk and not to abnormal increases in the amounts of tops and leaves or the production of new shoots to the stool. In this the effect of nitrogenous manures on the sugar-cane are very similar to those on others of the *Graminaceae.*

(9) Mineral phosphates, to give increased yields, must be applied to the soil in such heavy dressings as to render their use unprofitable.

(10) The addition of potash, when applied either as sulphate or as nitrate of potash, exerts little or no effect. The normal weathering of the constituents of the soil while under good tillage sets free for each crop potash in excess of the quantity necessary for the requirements for the plants. This holds good under the conditions existent in British Guiana, where the greater proportion of the potash taken up by the plants is directly returned to the soil, but where practically the whole of the produce is removed from the land it is probable that partial potash exhaustion may take place in the course of a succession of crops of sugar-cane.

These general principles appear to be applicable not only to the Bourbon variety but to the majority of, and probably to all, the new varieties I have submitted to experiment. Several of these latter appear to be able to utilize the nitrogen in the deeper layers of the soil to better advantage than the Bourbon cane does, and this is a matter of great importance with regard to the economical production of sugar from the sugar-cane.

BARBADOS.

Professor D'ALBUQUERQUE: I should like, on rising, to express, on behalf of my colleague and myself, and I think I may say, on behalf of all those who are working on Sugar-cane Experiments, our great regret at the absence of one whom we look upon as the doyen of the workers in that field. I mean Professor Harrison. I have listened, in common with other members of this Conference, with great pleasure to Professor Harrison's valuable paper. I should like Professor Harrison himself to have read that paper before the Conference, because whenever he gives us a paper there is so much that is new and of value in it, that it would be of advantage if we could discuss those new and valuable points. It is a gratification to observe the great progress that has been made in experiments with seedling canes in British Guiana. It is only fit that the practical results of the discovery of Professor Harrison and my colleague Mr. Bovell should be so obvious and so valuable in the colony in which one of those workers has laboured for so many years.

Coming now to the experiments in Barbados, and speaking on behalf of Mr. Bovell and myself, I think that most of those interested in Sugar-cane Experiments have already been able to read on more than one occasion the methods that we adopt for carrying out our work, and I do not think it would be the wish of this Conference that I should recapitulate them. I shall therefore proceed at once to summarize as briefly as possible the results of the experiments carried on in recent years.

These experiments have been directed mainly towards two ends, the raising of improved varieties, and the improvement of the methods of manuring and cultivation of existing varieties. Under the first heading come the raising of improved varieties from seed and the attempted improvement of existing varieties by chemical selection of the seed-cane. Under the last heading come manurial experiments and experiments upon tillage. Including the two central experimental stations, Dodds and Waterford, eighteen estates have, from time to time, been used for experimental purposes.

SEEDLING CANES.

During the six years ending December 1904, over 20,000 varieties of cane have been raised from seed and planted out.

In accordance with the systematic plan decided on at the beginning, they have been, or are being, in the first place, subjected to a process of field selection with the object of eliminating from further cultivation all but those that possess field characters more favourable than the average.

Early in 1904, about 6,000 of these varieties reached a second or third stage at which each variety is crushed and the juice analysed. These may be called the stages of chemical selection, and their object is to eliminate all varieties except those possessing juice sufficiently rich and pure, from the point of view of the manufacturer, to justify further cultivation. Only a few 'stools' of each variety can be reaped at these stages, and the results can therefore be regarded only as relative indications of the value of the varieties tested. Favourable examples of these stages reaped in 1903 and 1904 are given below.

TABLE I.

1903.

	Name of Variety.	Number of Stools cut.	Tons per acre. Canes.	Tons per acre. Estimated yield of Muscovado Sugar.	Juice. Crystallizable Sugar. Pounds per gallon.	Juice. Quotient of Purity.
Series A.	White Transparent	—	29·68	2·52	1·855	86·40
	B. 1,376	—	32·22	3·08	2·113	91·91
Series B. (1st. ratoons.)	White Transparent	—	19·05	1·55	1·738	85·62
	B. 147	—	19·05	1·73	1·869	91·53
	B. 1,607	—	26·18	2·13	1·680	81·36
Series C.	White Transparent	—	17·37	1·51	2·095	91·13
	B. 147	—	20·45	1·71	1·844	86·37
	B. 1,529	—	20·61	2·03	2·406	92·68
	B. 1,753	—	24·03	1·92	1·993	88·07
Series D.	White Transparent	—	20·67	1·73	1·939	88·42
	B. 147	—	24·52	2·14	1·866	85·52
	B. 1,143	—	31·94	2·53	1·955	88·66

TABLE II.

1904.

		Name of Variety.	Number of Stools cut.	Tons per acre. Canes.	Tons per acre. Estimated yield of Muscovado Sugar.	Juice. Crystallizable Sugar. Pounds per gallon.	Juice. Quotient of Purity.
Series A.		White Transparent	30	40·88	3·48	1·886	87·40
		B. 3,224	30	41·23	3·77	1·994	90·68
Series B.	100	White Transparent	30	39·22	3·42	1·928	89·09
	131	B. 1,030	30	53·04	4·48	1·931	88·98
	126	B. 1,528	30	48·42	4·31	1·947	89·72
	145	B. 1,529	30	47·42	4·96	2·321	92·80
	137	B. 1,753	30	57·91	4·68	1·879	88·01
	149	B. 3,289	30	57·69	5·09	1·895	88·51

It will be seen from Table II that in 1904, six varieties, including the White Transparent, were cultivated in small plots in a very fertile field. The estimated relative yields, taking the White Transparent at 100 as the standard are:—

White Transparent 100
B. 1,528 126
B. 1,030 131
B. 1,753 137
B. 1,529 145
B. 3,289 149

These results are favourable, but at this stage the figures can be employed only to point out what varieties are deserving of trial in the following stages.

In the fourth stage a few of the best varieties of preceding stages, together with the standard White Transparent variety, are cultivated in duplicate plots of 100 stools in each of the typical localities of the island. These experiments are carried out on sugar plantations and in all respects the cultivation is that of the plantation itself. At this stage, therefore, the

experiments, in so far as the small scale will allow, come under ordinary agricultural conditions. Some of the earlier seedlings, such as B. 147 and B. 208, have undergone some years of trial in such plots, and as a result are now in successful cultivation in various of the West Indian Colonies, as well as in other parts of the world.

The following table, taken from p. 35 of Pamphlet No. 32 of the Imperial Department of Agriculture, *Seedling and other Canes at Barbados, 1904*, gives the average results during 1900-4 of some of the best of the earlier varieties cultivated as selected seedlings on small estate plots :—

TABLE III.

1900-1904.

Variety.	Yield of Saccharose in pounds per acre.			Purity of Juice.
	Plants.	Ratoons.	Average.	
Black Soils :				
B. 208	6,989	3,626	5,307	high
B. 147	6,941	3,500	5,220	fair
White Transparent	6,675	3,040	4,857	high
Sealy Seedling ...	6,447			low
B. 376	6,353			high
B. 645	5,767			fair
D. 95	5,157	4,114	4,635	high
B. 379		2,067		high
Red Soils :				
B. 208	7,071	4,762	5,916	very high
B. 376	6,386			fair
Sealy Seedling ...	6,349			low
D. 95	5,693	5,611	5,652	high
White Transparent	5,373	4,386	4,879	high
B. 147	5,090	2,870	3,980	fair
B. 379		5,557		very high

In black soils at Barbados for the most part plant canes are alone cultivated. The following, therefore, are the relative results during these four years of some of the best selected seedlings grown as plant canes in black soils, taking the White Transparent variety at 100 as the standard :—

White Transparent	100
B. 147	104
B. 208	105

In red soils the following were the corresponding average results for plants and ratoons :—

White Transparent	100
D. 95	116
B. 208	121

The average results of B. 147 in red soils place that variety below the White Trasparent.

It should be pòinted out, and reference to the above-mentioned pamphlet will show, that the best variety judged by the average of all localities is not necessarily the variety that will give the best results on a particular estate. The planter should ascertain from the reports the varieties that give the best results in his locality, and in the first place give them a trial. In this way he will adapt the results to the circumstance of his own cultivation. This conclusion is well pointed by the results obtained with B. 147, which are much better in one or two parishes of Barbados than elsewhere in that island. In these parishes the increased yield is far beyond the average quoted above, and has been such as to justify one large proprietor in planting it on a large scale on several estates.

The reports upon selected seedling plots afford planters the means of selecting seedlings for trial on a small estate scale and full advantage is taken of the opportunity. To aid in this, the Government Laboratory undertakes the analysis of samples of the juice of such varieties sent from the estate mills. The results are published in the annual reports and serve as a further means of estimating the value of the varieties.

Arrangements have recently been made with the Government of Barbados to supply water for the limited irrigation of the first growth of seedling canes during the dry months when so many die off for want of moisture. This will enable, as in British Guiana, the original seedling stool to come to maturity and be reaped and analysed, and its relative value ascertained. In this way, the process of selection and elimination will greatly be accelerated, and it is hoped that thereby there will be a saving of at least two years in the testing of new varieties.

ARTIFICIAL CROSS FERTILIZATION.

In a paper on this subject in the *West Indian Bulletin* (Vol. I, pp. 185-7) one of us suggested various ways in which an attempt might be made to raise seedlings of which both parents were known, in place of the present methods in which only the mother variety is known with certainty. One suggestion was that the anthers should be removed from the immature flowers of one variety, which should be subsequently protected by a fine muslin bag from wind-borne pollen, and when ripe fertilized by pollen from the flowers of another and known variety.

This experiment has been successfully carried out last November by Mr. Lewton-Brain, Mycologist on the staff of the Imperial Department of Agriculture, who worked with some of the most promising varieties of Barbados seedlings. A very

small proportion of the seed germinated, but sufficient to justify a continuation of the experiment next season on a much larger scale.

The method of carrying out this experiment is described by Mr. Lewton Brain as follows :—

'The attempt, made in November 1904, to raise hybrid sugar-cane seedlings, by artificially cross-pollinating the flowers was undertaken rather with a view to determining whether such a process were practicable, than with the hope of obtaining any present results.

'The experiment was carried out in the experimental field at the Ridge plantation, Christ Church, Barbados. The canes operated on were some of one of the newer seedling varieties B. 1,529 which had given the best results in the previous year's experiments.

'A strong, moveable platform was constructed, 8 feet high, the top being 6 feet by 4 feet. On this there were boxes of different sizes, which served as tables and stools of varying height. The stamens were removed under the dissecting microscope, and the chief difficulty was found to be that of keeping the spikelets steady under the lens, while the work was going on.

'Arrows which were just beginning to emerge from the upper leaf-sheath were always selected. The cane was bent over carefully to the table and tied firmly to neighbouring canes and to the platform. The lower part of the arrow was placed in a clamp, the foot of which was then screwed into the top of the platform. All this had, of course, to be done with the greatest care, so that no undue strain was put upon any part of the cane.

'The table and dissecting microscope were then shifted into as convenient a position as possible, and the stamens were removed from about a dozen to twenty spikelets, preferably on several branches of the arrow. This operation proved to be one of some difficulty and delicacy under field conditions; frequently the stigmatic plumes were removed or injured before the third stamen could be got out. It was found necessary to work with one's back to the sun to avoid the glitter from the glumes and hairs.

'The remaining spikelets on the arrow, including, of course, all those that had emerged into the air before the operation, were then removed.

'Meanwhile a strong pole, 10 feet high from the ground, had been fixed near the base of the cane. To this, near the top, was fixed a wire cage sufficiently large to include easily the whole arrow, the cage was made in two halves which were left sufficiently apart to admit the arrow. The cane was now gently and gradually released, and the arrow brought into the cage: this was then closed and covered with fine, strong muslin. The whole was sewn up carefully, and the cane and arrow tied up to the pole, in some cases too great strain was put upon the upper part of the cane in the tying, and the arrow dried up. A few days later, when the stigmatic plumes

were seen to be turning red and opening out, pollination was performed, and the muslin again sewn up.

'The whole process is tedious and one that requires great care and delicacy at every point. Under the conditions this is not always easy. Even then a sudden gust of wind or a sudden shower of rain may spoil a morning's work.

'The result has been that four seeds germinated. Considering that normally the percentage of germination among sugar-cane seeds is extremely low, this may be considered fairly satisfactory. At any rate it is proved that the raising of hybrid sugar-canes by artificial cross-fertilization is not impossible, but it is also evident that, to get sufficient seedlings to work with and select from, experiments must be carried out on a much larger scale than was the present one.

'At the same time that the above work was in process, other arrows were enclosed in similar fashion without emasculation. When the spikelets were opening other arrows from the same variety of cane were introduced into the bags for their pollination. A number of seedlings have been raised from them, and these will be the first seedling canes raised in the West Indies whose parentage is a matter of certainty.'

The authors of this summary regard the results of this attempt as affording important means of accelerating the work with seedling canes, since it is thereby possible to ensure that the parents of the seedling are both varieties of known and favourable characters.

ATTEMPTS TO IMPROVE EXISTING VARIETIES BY CHEMICAL SELECTION OF THE 'SEED-CANE.'

During the period 1900-4 a continuous series of experiments has been carried on with the object of ascertaining whether it is possible, by repeatedly selecting plants from the richest plants of a given variety, gradually to increase the average richness of the variety.

The difficulties in carrying out such an attempt were pointed out by one of us in the *West Indian Bulletin*, Vol. 1, pp. 185-7.

The following is a brief account of the experiments and the results :—

Irrigated fields were used in order that the planting could take place at the same time as the reaping. The ordinary reaping season in Barbados (March-May) is too dry for planting unless irrigation is available.

The variety planted was B. 147.

The lower half of each cane was analysed, and the upper half divided up into 'top' and portions containing two or three joints for plants. The stools and the canes were numbered. The richest stools formed one class, called high stools, the poorest another, called low stools, and the intermediate stools were rejected. The richest canes of the richest stools were planted, the other canes of the rich stools being rejected. The poorest canes of the poorest stools were planted and the other canes of the poor stools were rejected. Thus the 'high plots'

were planted with the richest canes of the richest stools, and the 'low plots' with the poorest canes of the poorest stools.

This process has been repeated for four consecutive plantings. In the second and subsequent plantings, the highest canes of the highest stools of the 'high plot' were taken for replanting the 'high plots', and the lowest canes of the lowest stools of the 'low plot' were taken for the 'low plots.'

In this way, it was hoped that at each reaping the crop canes of the high plots would be somewhat richer than those of the low plots, and that at each successive crop the difference between the high and low plots would become greater and greater, since the effect of each year's selection would be to make the high plot richer and the low plot poorer.

The results up to the reaping of 1904 are given below :—

1900-2.

High plots	seed-canes	average	℔	per	gall	saccharose	212
	crop-canes	,,	,,	,,	,,	,,	193
Low plots	seed-canes	,,	,,	,,	,,	,,	190
	crop-canes	,,	,,	,,	,,	,,	184

1902-3.

High plots	seed-canes	average	℔.	per	gall	saccharose	212
	crop-canes	,,	,,	,,	,,	,,	184
Low plots	seed-canes	,,	,,	,,	,,	,,	145
	crop-canes	,,	,,	,,	,,	,,	190

1903-4.

High plots	seed-canes	average	℔.	per	gall.	saccharose	1·93
	crop-canes	,,	,,	,,	,,	,,	1·94
Low plots	seed-canes	,,	,,	,,	,,	,,	1·65
	crop-canes	,,	,,	,,	,,	,,	1·96

1904-5.

High plots	seed-canes	average	℔.	per	gall.	saccharose	2·11
	crop-canes	,,	,,	,,	,,	,,	—
Low plots	seed canes	,,	,,	,,	,,	,,	1·59
	crop-canes	,,	,,	,,	,,	,,	—

In our opinion, taking into account the necessary errors of the experiment, these results fail to show any difference between the richness of the juice of the high plots and the low plots. In other words, it appears that, with a given variety, the richness or poorness of the seed-cane does not affect the quality of the juice of the resulting crop. If these results are confirmed by subsequent experiments, one of two conclusions seems inevitable. Either it is impossible, on account of disturbing influences, to ascertain the relative potential richness of individual canes of the same variety, or the average richness of a given variety is a constant property of the variety, and not capable, under ordinary conditions, of being influenced by making use of the ordinary variations, such as are found in seed-cane. The latter seems to us the more probable conclusion, a conclusion which is in harmony with the results in British Guiana of Professor Harrison, who concludes that the relative richness of seedlings is qualitatively, if not quantitatively, constant.

MANURIAL EXPERIMENTS.

During the period 1899-1904, experiments have been carried on at eight typical plantations, and a total of 2,738 plots have been reaped.

These experiments, which have comprised plant canes and 1st. and 2nd. ratoons, have occupied the following areas :—

Season.			Area in acres.
1898-1900	...	...	12·6
1899-1901	...	...	20·0
1900-2	...	...	17·5
1901-3	...	...	62·0
1902-4	..	...	49·0

The results have shown considerable differences in different seasons and different localities. They may be stated in the following general terms :—

(1) Land that received no farmyard manure showed substantial increase in yield as the result of the application of artificial manures, containing nitrogen, phosphoric acid, and potash.

(2) In the case of land that had received large applications of farmyard manure, nitrogen as a rule, was the most important ingredient of artificial manures applied either to plant canes or ratoons.

(3) The application of phosphoric acid in the form of superphosphate or of basic slag in a few instances was followed by moderate or large increase of the returns, but in the majority of cases, it had either a very small effect or no effect.

(4) Potash in the form of sulphate of potash produced in many cases increased returns.

(5) Sulphate of ammonia appears in many cases to be slightly superior to nitrate of soda.

(6) At Dodds, the early application of dried blood has, in some seasons, given better results than other forms of nitrogen.

(7) The application of nitrogen, phosphoric acid, or potash appears to have no direct effect upon the composition of the cane juice. The beneficial effect of such applications apparently depends upon increase of cane growth. If, however, the nitrogen is applied too late, it retards or prevents the ripening of the cane, and so may lead to comparatively poor and impure juice.

(8) The application of slaked lime to the extent of half a ton per acre was followed, even in land that was rich in carbonate of lime, by substantial increase in the crop : a result apparently due to an improvement in the physical condition of heavy clay soils.

(9) The monetary result of the application of one or other constituent of artificial manures is so greatly dependent upon the market price of sugar, that it is difficult to make a simple statement of general utility for Barbados. The profit on manuring is the value of the increase of canes less the cost of

the manure, and less the cost of manufacture. A manuring which, in one year at one market price, gives a profit, may, in other years, result in loss.

The following recommendations appear to be those most generally applicable :—

(1) Where early cane manure is to be applied, the farmyard manure should be applied to the land at an interval of two or three months before the early cane manure.

(2) In the case of land that has been well manured with farmyard manure, apply soon after planting the canes 1 cwt. of sulphate of potash per acre.

(3) To the land that has received insufficient farmyard manure, or that is known to be deficient in available phosphoric acid, apply soon after planting the canes, 1½ cwt. of superphosphate (containing 40 per cent. available phosphate) or 2½ cwt. of good basic slag.

(4) In June, that is, at the beginning of the period of most active growth, apply 2 cwt. of sulphate of ammonia. In July or August, if, after heavy rains, the canes turn pale in colour, apply a further 1 cwt. of sulphate of ammonia.

(5) To ratoons, soon after the stumps begin to spring, apply 1 cwt. of nitrate of soda, 1 cwt. of sulphate of potash with or without 1½ cwt. of superphosphate according to the land. In June, apply 2 cwt. of sulphate of ammonia. A further application not later than August of 1 cwt. of sulphate of ammonia should only be made, if, after having heavy rains, the pale colour of the canes renders it likely that more nitrogen would be beneficial.

EXPERIMENTS ON TILLAGE.

A series of duplicate experiments was carried out during the season 1901-3 at Hampton plantation with a view of comparing the results of ordinary hand tillage, such as is practised in Barbados, with those of tillage with ordinary ploughs, subsoilers, American disc ploughs and cultivators. The results were in favour of hand tillage to the extent of about 500 lb. sugar per acre, an amount that, in Barbados, would more than cover the extra cost of hand labour.

LEEWARD ISLANDS.

Dr. Francis Watts : These experiments may be classed in two periods. In 1891 experiments were instituted in Antigua to ascertain the manurial requirements of the sugar-cane and also to discover suitable canes for cultivation in that presidency. These were carried on until 1898.

This period covered the anxious time when cane diseases were rampant, and it seemed quite possible that the sugar industry would be seriously crippled or ruined.

It was difficult to draw reliable conclusions from the results of the manurial experiments of that period, for the canes on the various plots were so badly attacked by disease, principally 'rind fungus' (*Trichosphoeria*), as to make the results uncertain or contradictory, still by careful scrutiny we were able to arrive at some general conclusions.

These experiments, however, had a distinct value and served to settle some points in the public mind. It was seen that there was no relationship between the manures used and the occurrence of the cane disease, that manures neither caused it, nor could cure it. The canes of the plots being under close observation afforded useful information concerning the disease in a general way.

Under these circumstances, the experiments with varieties of sugar-cane at once assumed considerable importance, for on our experiment plots planters could see for themselves that certain varieties of canes were highly resistant, if not quite immune. I well remember an excellent demonstration where a plot of Bourbon canes grew side by side with a plot of White Transparent, so that the canes on the boundary interlaced; on the Bourbon side it was difficult to find a sound cane, while among the White Transparent it was equally difficult to find a diseased one. This was convincing and the lesson was speedily applied in practice.

Upon the formation of the Imperial Department of Agriculture for the West Indies the experiments were placed upon a broader basis and extended to the neighbouring presidency of St. Kitt's.

Instead of being carried on at only one station, the plan was now followed of having in each island a central station, and also a number of secondary stations on various estates, both for manurial experiments and for the cultivation of varieties.

The wisdom of this has been questioned by some of our critics who urge that more good would be done by having one well-equipped central station where there could be carefully applied scientific control, and experiments of a higher order would be carried out. I admit that this is most attractive to the scientific worker and personally, so far as doing the work is concerned, I should prefer it; but I feel perfectly assured that results, however accurate, obtained at such a station would fail to carry conviction to the mind of the ordinary planter. He would regard such a scientific station as a thing apart, having very little bearing upon him or his work. Perhaps in time, and largely as the outcome of the science teaching now available in our secondary schools, and of the introduction of improved methods of manufacture, we may hope for good ground on which to proceed to higher things, of which a scientific central station of high order may be one.

At present it is our chief concern to bring our experiments and their results under the notice of every practical planter; this I think, we best secure by obtaining the co-operation of the planters themselves. Under existing conditions the

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planters grow the canes in fields of their own preparing, they cultivate them in the same manner as their ordinary canes, and, knowing their history from start to finish, while participating generally in the work, their interest is stimulated and they can, and do, draw their own conclusions and apply the results of their observations directly to their daily practice.

I am pleased to be able to say that the planters welcome this line of work and co-operate gladly. I take this opportunity of thanking them and also of urging them to continue with even more interest as tending to their own immediate advantage.

EXPERIMENTS WITH VARIETIES OF SUGAR-CANE.

Working in this way we have in Antigua a central station and seven secondary stations. At the latter experiments with selected varieties both as plants and ratoons are carried on. In St. Kitt's, we have also a central station with seven secondary stations.

In judging our results it has been our custom to base our conclusions largely upon the quantity of sugar which the canes will yield when crushed. While observing the peculiarities of any cane and its suitability, or otherwise, we base our general conclusions on the average results of all the plots in each island. It has been our custom to take into account the record of the cane in previous seasons and to calculate the average yield of sugar over periods covering the experiments of several years. For example, in Antigua in our latest report, we give the mean results with plant canes for three years, wherein *each* cane has been experimented with forty-four times. The experience thus gained should be of considerable value, both as eliminating errors and giving the results of different seasons, the latter being of the greatest importance, for it is for average conditions that the planter must provide.

In the report for last season, now in the press, I have also instituted another method of comparison which appears to yield useful and interesting results.

The canes at each station are arranged in the order of the yield of sugar, the list is then divided into three sections, those in the upper section are regarded as above the average, those in the middle section as of average merit, and those in the lowest section as below the average. By noting which canes come in the first section at the various stations and selecting those which occur in this portion at the largest number of stations, we can ascertain which canes are best suited for general distribution in a given district, such as is presented by one of our small islands.

TABLE I.

ANTIGUA.—PLANT CANES.

Means for three years.—Deduced from 44 Plots of each variety of Cane.

No.	Name of Cane.	Means of sucrose in pounds per acre for three years.
1	B. 208*	10,828
2	B. 156	9,778
3	Sealy Seedling	9,655
4	B. 306	9,599
5	B. 109*	9,489
6	D. 95	9,351
7	D. 130*	9,141
8	D. 74	9,427
9	D. 102	8,333
10	Mont Blanc	8,271
11	White Transparent	7,968
12	D. 145†	7,896
13	Rappoe	7,890
14	Naga B.	7,833
15	Caledonian Queen	7,714
16	Burke	7,693
17	D. 116	7,672
18	Red Ribbon*	7,517
19	D. 115*	7,409
20	Queensland Creole*	7,389
21	D. 78*	6,879
22	B. 147*	6,727

* Mean of 43 Plots only.
† Mean of 37 Plots only.

TABLE II.

ANTIGUA.—RATOON CANES.

Means for two years.—Deduced from 23 Plots of each variety of Cane.

No.	Name of Cane.	Means of sucrose in pounds per acre for two years.
1	B. 109...	6,162
2	Sealy Seedling	6,065
3	B. 306...	5,866
4	B. 208...	5,769
5	D. 95...	5,595
6	D. 130...	5,335
7	D. 102...	5,333
8	B. 156...	5,246
9	Mont Blanc	5,050
10	Rappoe	4,931
11	D. 74...	4,872
12	Burke...	4,880
13	White Transparent	4,816
14	Naga B.	4,719
15	D. 115...	4,716
16	D. 147...	4,680
17	D. 116...	4,616
18	D. 78...	4,587
19	Caledonian Queen	4,499
20	Queensland Creole	4,203

Table III.

ST. KITT'S.—PLANT CANES.

Means for four years.—Deduced from 29 Plots of each variety of Cane.

No.	Name of Cane.	Means of sucrose in pounds per acre for four years.
1	B. 208	9,025
2	Naga B.	8,138
3	Caledonian Queen*	7,858
4	Mont Blanc	7,775
5	D. 116	7,686
6	D. 74	7,683
7	D. 115	7,586
8	B. 306	7,535
9	Rappoe...	7,526
10	B. 393	7,400
11	B. 376	7,348
12	Jamaica	7,345
13	B. 147	7,344
14	Queensland Creole	7,304
15	D. 95	7,211
16	B. 109	7,115
17	White Transparent	6,884
18	B. 254	6,229

*Mean for three years only, deduced from 23 plots.

TABLE IV.

ST. KITT'S.—RATOON CANES.

Means for three years.—Deduced from 20 Plots of each variety of Cane.

No.	Name of Cane.	Means of sucrose in pounds per acre for three years.
1	B. 306	6,521
2	D. 115	6,429
3	B. 208	6,369
4	D. 95	6,195
5	B. 147	6,143
6	Jamaica	5,930
7	Naga B.	5,899
8	D. 74	5,882
9	White Transparent...	5,698
10	D. 116	5,647
11	B. 376	5,513
12	Rappoe	5,377
13	Mont Blanc	5,339
14	B. 393	5,320
15	B. 109	5,179
16	Queensland Creole	5,122
17	B. 254	4,894

As the result of our experiments, we recommend for cautious introduction into Antigua: B. 208, B. 156, Sealy Seedling, B. 306, B. 109, and D. 95. Of the promising canes grown at the central station we would direct attention to B. 376, T. 211, and D. 109, though these canes have not yet been tried on a sufficient scale for us to speak with any degree of assurance as to their merits.

In St. Kitt's, the following canes appear to be worthy of consideration: B. 393, B. 208, D. 74, White Transparent, B. 109, and B. 306. To these we must add B. 147 which has given excellent results over large areas, though it occupies a somewhat low place in our experiments. Of these D. 74, White Transparent, Mont Blanc, and B. 306 appear to be fairly resistant to drought, while B. 208 appears to require a greater rainfall.

Those who are interested in these questions are referred to our full reports published annually, or to the pamphlets in which the main facts are put forward divested of many technicalities.

Great interest is taken in these experiments by the planters who, by following up our experiments by plots and fields of selected varieties, carry our results a stage further and add to our knowledge.

We are desirous of adding selected varieties to our main collections in the hope of finding new canes possessing characters to commend them to our planters. We have just received a useful and welcome addition to our stock in the form of a collection of twenty varieties from British Guiana and a collection of twelve varieties from Barbados, for which we desire to tender or thanks to the officers in charge of those stations.

We are making efforts to raise new seedling canes; in the earlier years we found great difficulty in raising seedlings in Antigua, the dry climate presenting obstacles. We have now, however, a collection of several hundred Antigua seedlings in process of cultivation and selection, but are not yet in a position to put forward critical results concerning them, but we believe we have amongst them canes of good promise.

For some years we have carried on experiments to ascertain whether it is possible to increase the saccharine richness of the sugar-cane by selecting for planting canes rich in sucrose. For purposes of comparison, and as affording a standard of measurement, we have carried on a similar series of experiments to ascertain if, by the same process of selection, the saccharine richness of the cane can be decreased. For the details of our work those interested are referred to our annual reports and pamphlets.

We now have the results of four successive plantings and reapings which have given the following results:—

	Planted 1900.	Reaped 1901.	Planted 1901.	Reaped 1902.	Planted 1902.	Reaped 1903.	Planted 1903.	Reaped 1904.
High canes* ...	2·296	1·925	2·113	2·011	2·290	2·128	2·304	2·136
Low canes* ...	1·699	1·905	1·587	1·793	1·305	2·035	1·841	1·937
Difference on canes planted.	·597	...	·526	...	·985	...	·463	...
Difference on canes reaped.	..	·020	...	·218	...	·093	...	·199

We are well aware of the difficulties and uncertainties of experiments along these lines, still, regarding the results with all due caution, it would appear that some difference is induced by the process of selection and, while this method of work is not likely to be followed by practical planters as a means of improving their canes, yet the fact is interesting from its scientific aspect as indicating that plants propagated by cuttings are subject to slight alterations.

MANURIAL EXPERIMENTS.

We are of opinion that it is only by the manifold repetition of a series of experiments carried on year after year that results of any value can be obtained in connexion with the important questions involved in the manurial experiments of the sugar-cane. Consequently, soon after the formation of the Imperial Department of Agriculture for the West Indies we laid down an extensive series of experiments to be carried out on plant and ratoon canes.

Table V shows the mean results from thirty-eight plots for four years (1900-4). The same results are indicated in diagrammatic form in Diagram I. In this diagram, as in Diagram 2, a black line is produced opposite to each of a series of numbers. Each number refers to a manurial experiment. The black line by its length represents the amount of cane sugar per acre obtained in the juice of the plots on which the experiment in question was carried out. The diagrams, however, indicate more than this. The lines are broken by a thin white space. The small portion of the line thus broken off is proportional to the amount of sugar corresponding to the cost per acre of the manure applied to each plot. The length of black line to the white space therefore indicates the net result per

* 'High' canes are those in the experiments seeking for increased saccharine content, while 'low' canes are those in which decreased saccharine richness is sought.

acre obtained on the plot after deducting the cost of the manure, thus giving the information of most importance to the planter.

These experiments are some thirty-six in number and they are laid out in duplicate on three stations in Antigua with plant canes and either on two or three stations with ratoons, and on two stations in St. Kitt's with plant canes and on two with ratoons. We have accumulated these results over four years with plant canes and three years with ratoons. Consequently, each plant cane experiment has been repeated thirty-eight times and each ratoon experiment twenty-three times: thus affording a wide and, we believe, an adequate basis for useful comparisons.

Those interested in these researches are referred to our annual reports or to the annual pamphlets: in the latter the information is put forward in brief manner, as far as possible divested of technicalities. There are, however, some salient points to which we may direct attention. We can only claim that our results are applicable to the conditions of the Leeward Islands. The peculiar features of other countries may render these conclusions inapplicable.

The first point of considerable interest which we think is demonstrated is that, if the soil is properly prepared and in its preparation an adequate quantity of good pen manure, or its equivalent, is used (about 20 tons of pen manure per acre), then artificial manures are neither necessary nor remunerative. This is a generalization of great importance to planters, particularly as it appears reasonable to urge that the use of pen manure, or its equivalent, is necessary in the Leeward Islands in order to maintain in the soil a sufficient supply of humus.

With ratoon cultivation the conditions are very different. There we find nitrogenous manures of great importance and necessary in order to obtain remunerative results.

The results of manurial experiments with ratoons are shown in Table VI and the corresponding diagram (no. 2).

DIAGRAM 1.—Corresponding with Table V.

Manurial Experiments with Plant Canes. Means of 38 Plots for four Years (1900-4).

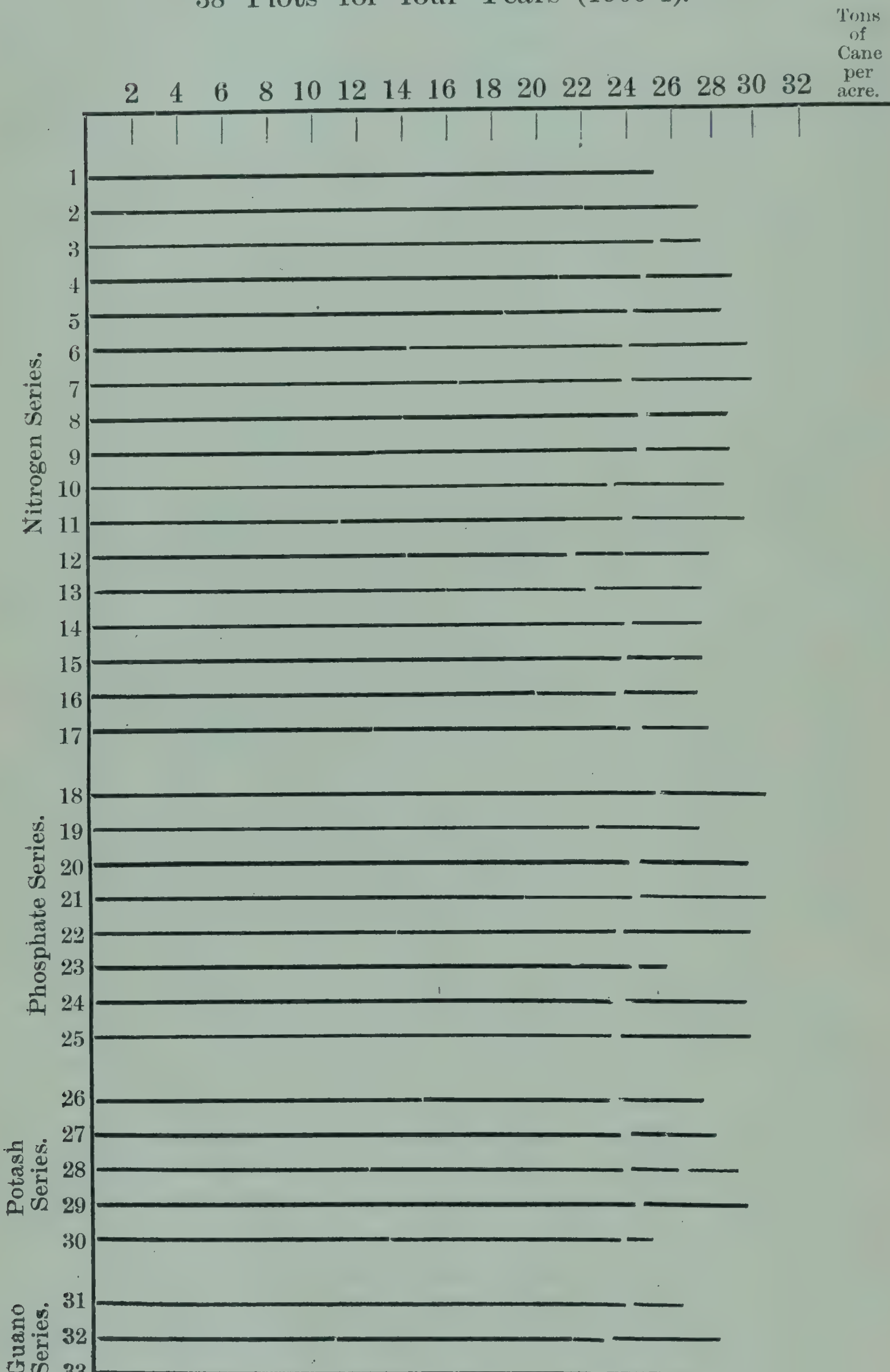


TABLE V.

MANURIAL EXPERIMENTS WITH PLANT CANES.

Means of 38 Plots for four Years (1900-4).

No. of Experiment.	Tons of Cane per acre.	Difference on No Nitrogen.	Difference on No Manure.
1	25·4	−1·9	...
2	27·4	+0·1	+2·0
3	27·3	...	+1·9
4	29·0	+1·7	+3·6
5	28·3	+1·0	+2·9
6	29·6	+2·3	+4·2
7	29·6	+2·3	+4·2
8	28·9	+1·6	+3·5
9	28·8	+1·5	+3·4
10	28·5	+1·2	+3·1
11	29·8	+2·5	+4·4
12	27·9	+ ·6	+2·5
13	27·3	+ ·0	+1·9
14	27·5	+ ·2	+2·1
15	27·7	+ ·4	+2·3
16	27·2	− ·1	+1·8
17	27·7	+ ·4	+2·3
18	30·5	Difference on No Phosphate.	+5·1
19	27·3	−3·2	+1·9
20	29·6	− ·9	+4·2
21	30·4	− ·1	+5·0

TABLE V.—*Concluded.*

MANURIAL EXPERIMENTS WITH PLANT CANES.

Means of 38 Plots for four Years (1900-4).

No. of Experiment.	Tons of Cane per acre.	Difference on No Phosphate.	Difference on No Manure.
22	29·8	– ·7	+ 4·4
23	25·4	– 5·1	+ ·0
24	29·7	– ·8	+ 4·3
25	29·9	– ·6	+ 4·5
26	27·7	Difference on No Potash.	+ 2·3
27	28·3	+ ·6	+ 2·9
28	29·3	+ 1·6	+ 3·9
29	29·6	+ 1·9	+ 4·2
30	25·1	– 2·6	– ·3
31	26·6	...	+ 1·2
32	28·1	...	+ 2·7
33	27·5	...	+ 2·1

TABLE VI.

MANURIAL EXPERIMENTS WITH RATOONS.

Means of 20 Plots for three Years (1901-4).

No. of Experiment.	Tons of Cane per acre.	Difference on No Nitrogen.	Difference on No Manure.	Value of Increment.	Cost of Manure.	Profit or Loss on Manuring.	
		Tons.	Tons.	$ c.	$ c.	$ c.	s. d.
1	11·7	– 1·9	...	...	...	...	...
2	14·0	+ 0·4	+ 2·3	5·98	...	...	...
3	13·6	...	+ 1·9	4·94	5·18	– 0·24	– 1 0
4	17·7	+ 4·1	+ 6·0	15·60	11·36	+ 4·24	+ 17 8
5	16·3	+ 2·7	+ 4·6	11·96	11·36	+ 0·60	+ 2 6
6	18·9	+ 5·3	+ 7·2	18·72	14·45	+ 4·27	+ 17 9
7	17·0	+ 3·4	+ 5·3	13·78	14·45	– 0·67	– 2 9
8	18·1	+ 4·5	+ 6·4	16·64	10·94	+ 5·70	+ 23 9
9	17·2	+ 3·6	+ 5·5	14·30	10·94	+ 3·36	+ 14 0
10	18·8	+ 5·2	+ 7·1	18·46	13·82	+ 4·64	+ 19 4
11	18·0	+ 4·4	+ 6·3	16·38	13·82	+ 2·56	+ 10 8
12	16·2	+ 2·6	+ 4·5	11·70	16·33	– 4·63	– 19 3
13	15·1	+ 1·5	+ 3·4	8·84	12·57	– 3·73	– 15 6
14	18·0	+ 4·4	+ 6·3	16·38	9·27	+ 7·11	+ 29 7
15	17·1	+ 3·5	+ 5·4	14·04	9·27	+ 4·77	+ 19 10
16	18·4	+ 4·8	+ 6·7	17·42	8·64	+ 8·78	+ 36 7
17	16·8	+ 3·2	+ 5·1	13·26	8·64	+ 4·62	+ 19 3
18	18·3	Difference on No Phosphate.	+ 6·6	17·16	12·57	+ 4·59	+ 19 1
19	15·1	– 3·2	+ 3·4	8·84	12·57	– 3·73	– 15 6
20	18·9	+ ·6	+ 7·2	18·72	14·45	+ 4·27	+ 17 9
21	19·0	+ ·7	+ 7·3	18·98	15·39	+ 2·59	+ 10 9

TABLE VI.—*Concluded.*

MANURIAL EXPERIMENTS WITH RATOONS.

Means of 20 Plots for three Years (1901-4).

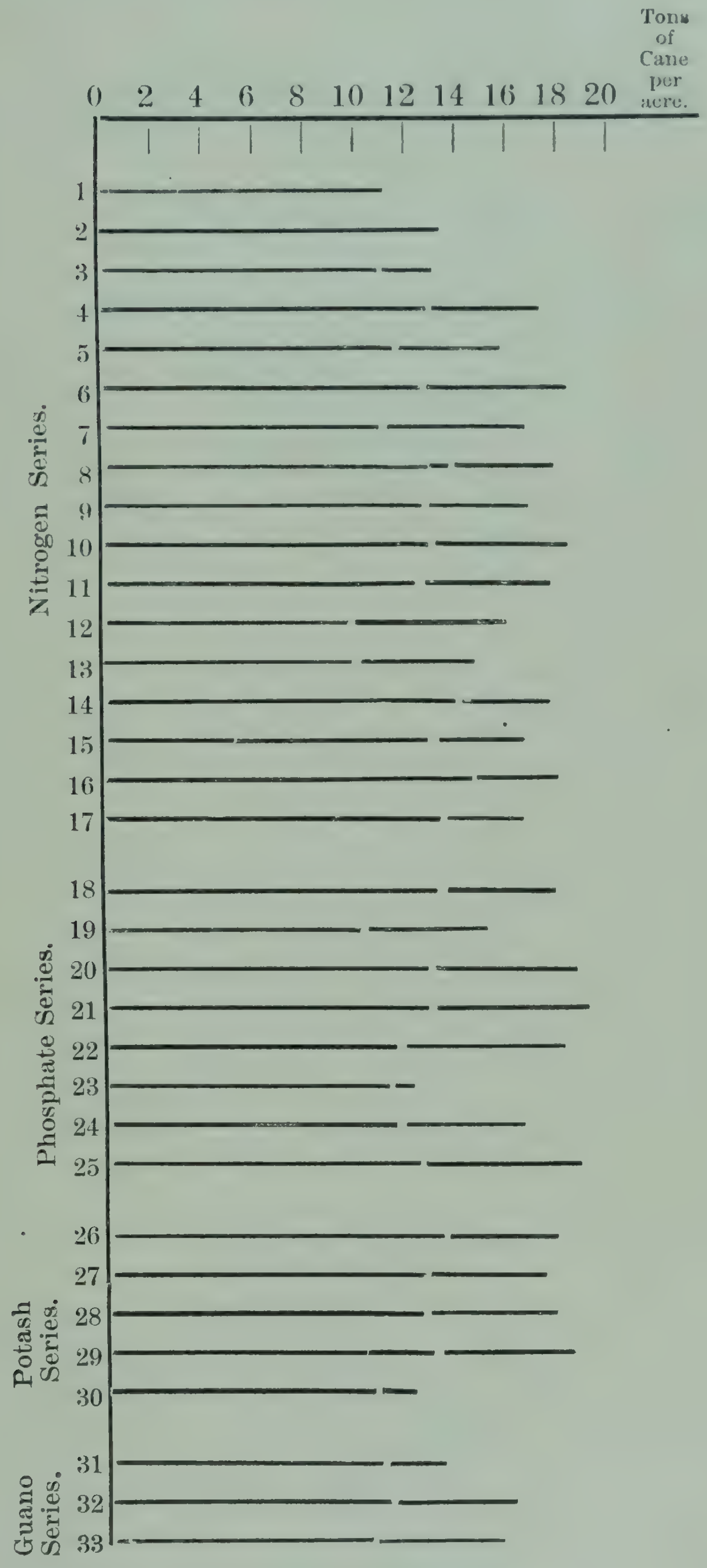
No. of Experiment.	Tons of Cane per acre.	Difference on No Phosphate.	Difference on No Manure.	Value of Increment.	Cost of Manure.	Profit or Loss on Manuring.	
		Tons.	Tons.	$ c.	$ c.	$ c.	s. d.
22	18·4	+ ·1	+ 6·7	17·42	16·33	+ 1·09	+ 4 6
23	12·5	− 5·8	+ ·8	2·08	1·88	+ 0·20	+ 0 10
24	17·9	− ·4	+ 6·2	16·12	15·29	+ 0·83	+ 3 5
25	19·3	+ 1·0	+ 7·6	19·76	16·65	+ 3·11	+ 12 11
26	18·0	Difference on No Potash	+ 6·3	16·38	11·15	+ 5·23	+ 21 9
27	17·7	− ·3	+ 6·0	15·60	12·25	+ 3·35	+ 13 11
28	18·1	+ ·1	+ 6·4	16·64	13·35	+ 3·29	+ 13 8
29	18·9	+ ·9	+ 7·2	18·72	14·45	+ 4·27	+ 17 9
30	12·3	− 5·7	+ ·6	1·56	3·30	− 1·74	− 7 3
31	13·7	..	+ 2·0	5·20	6·50	− 1·30	− 5 5
32	16·4	...	+ 4·7	12·22	13·00	− 0·78	− 3 3
33	15·7	...	+ 4·0	10·40	13·00	− 2·60	− 10 0

Some interesting points arise in connexion with the manner of applying nitrogenous manures. We find it more profitable to use all the nitrogenous manure in one application. A division of the dose into two always gives a smaller return, and sometimes to such an extent as to convert a possible profit into an actual loss. In our report for 1902-3 we put forward a hypothesis in an attempt to explain this circumstance.

Phosphatic manures are found to be unnecessary if an adequate supply of pen manure is used. This applies to plant canes and to ratoon canes. This result was unexpected, for the soils of the Leeward Islands are, generally speaking, deficient in phosphates : many additional experiments have been made in order to check this conclusion, which we now think is definitely established.

Potash is found to increase the yield somewhat, but in a doubtfully remunerative degree.

DIAGRAM 2.—Corresponding with Table VI.
Manurial Experiments with Ratoon Canes. Means of 20 Plots for three Years (1901-4).



It sometimes happens that a particular field in good condition requires to be planted, but that no pen manure or green dressing is available: under those circumstances the use of (to the plant canes) artificial manure containing nitrogen, either as sulphate of ammonia or nitrate of soda, together with a fair amount of potash and a small quantity of phosphate may be recommended.

These conclusions, though admitting of this brief statement, by way of summary, have not been reached except through a laborious amount of work. The information is, we think, sufficiently definite and conclusive to be of service to planters who are, by that means, enabled to direct their expenditure with considerable precision; a matter of great importance when competition is keen.

Our experiments over the three seasons 1900–3 afforded data whereby we could ascertain whether the nitrogen, phosphate, and potash exercised any marked influence upon the saccharine richness of the sugar-cane. As the result of the study of the data thus furnished, we arrived at the conclusion that the saccharine richness of the cane is not affected in any marked degree by the manures used, and that when any form of manure, in quantities likely to be used in actual practice, increases the weight of cane per acre, it increases, in the same proportion, the weight of sucrose. This leads to the conclusion, important to the planter and sugar-maker, that while it is useless to look for increased saccharine richness as the result of any form of manuring, it is, on the other hand, unnecessary to fear injury or falling off in quality from the use of such quantities of manures as can be profitably employed.

This study of our figures led to another important conclusion, namely, that we should have arrived at the same conclusions for the information of planters concerning the effects of artificial manures, had we used as our basis of comparison the weight of canes instead of the weight of cane sugar in the juice expressed. From this it follows that in future we can greatly simplify our work by putting aside as unnecessary the laborious analyses of hundreds of samples of cane juice and using the weight of cane produced as the basis of comparison between our various plots.

TRINIDAD.

On the invitation of the President Dr. A. Urich, Ph.D., F.I.C., Analyst and Technical Chemist to the Trinidad Estates Company, Limited, read the following paper on the 'Comparative yield of the Bourbon cane, White Transparent, and D. 95 at Brechin Castle estate, Trinidad, in 1904':—

The remarkable falling off of the favourite Bourbon cane on some estates in Trinidad makes its replacing by another variety a matter of such importance that the results obtained on one of the leading estates on a large scale with the White

Transparent and the D. 95 are the more interesting, as they comprise an area of 1,762 acres and are, therefore, more reliable than if obtained on mere experiment plots.

Brechin Castle estate, the property of the Trinidad Estates Company, Limited, is situated on the flat banks near Couva and was always known for the heavy crops of cane. Returns of 23 tons (long tons) cane per acre, all Bourbon, were frequent. The mean yield from 1895 to 1899 was 22 tons, which is comparatively high, considering the limited dose of 2 cwt. of fertilizers per acre. But since that time the yield sunk to 19 and 18·5 tons per acre, whilst an ever-increasing area practically refused to grow Bourbon.

There was nothing wrong in the chemical composition of the soil, neither could fungus, root disease, neglected drainage or tillage be made responsible for the failure, neither was it lack of fertilizing, for a dose of 3 cwt.* had been applied per acre. But it became imperative to replace the Bourbon by another variety. Frequent previous trials with White Transparent and D. 95 had given such encouraging results as regards tonnage that in 1904 the area cropped under Bourbon was reduced to 603 acres, whilst that under White Transparent had risen to 934 and that under D. 95 to 225 acres.

The Brechin Castle Usine is supplied with canes from three groups of estates which we will call A, B, and C. The difference of the soil is shown by the following analyses :-

	Light soil, per cent.	Medium soil, per cent.	Heavy clay, per cent.
Organic matter and combined water	4·80	7·60	10·35
Containing nitrogen	0·113	0·141	0·350
Sand and insoluble silicates ..	81·40	72·30	61·00
Moisture	2·20	3·70	6·20
Lime	0·325	0·269	0·857
Potash	0·433	0·439	0·762
Phosphoric acid	0·140	0·120	0·209
Available potash	0·027	0·020	0·022
,, phosphoric acid (soluble in 1 per cent. citric acid)	0·021	0·010	0·017

Rainfall in 1903 = 59 inches.

* The fertilizer was composed of 3·4 per cent. nitrogen as sulphate of ammonia, 2·5 per cent. nitrogen as nitrate of soda, 11 per cent. phosphoric acid from superphosphate, and 4·3 potash, costing $6 per acre.

In sections A and B medium and occasionally light soils prevail, whilst section C is a heavy clay.

The annexed statement was compiled from data kindly supplied by Mr. T. Arbuckle, the manager of the estate. It shows the yield in plant canes, first and second ratoons for each section of the estate. The term 'true average' means the calculated yield in cane per acre, had exactly the same area (one-third) been planted in plant canes, first and second ratoons.

The falling off of the Bourbon cane was noticed most in section A.

Section B still gave an average return of 17 tons, but the rich lands of C only gave 15·7 tons. In former years some fields of this section used to give a return of 40 tons (plant canes) per acre.

The purple cane D. 95 proved to be equally prominent as plant canes, first and second ratoons in section A, the very satisfactory return being 32·8, 21·2, and 20·9 tons respectively, equal to an average of 24 tons.

White Transparent shows a somewhat inferior but still satisfactory record in section A with 30·5 tons for plant canes, 20·7 for first and 14·3 for second ratoons. Average 23 tons. For sections B and C the average is 22·8 and 20·2 tons respectively. Taken as a whole, the 603 acres in Bourbon gave an average return of 16·43 tons per acre; 935 acres White Transparent, 22·35 tons per acre; and 225 acres D. 95, 23·65 tons per acre.

Thus far we have only considered the merits of the new varieties as regards tonnage, but an equally important item is their sugar contents. I regret not being able to supplement the above statement by the exact sucrose contents for each variety, much less the results obtained in manufacture. This was impossible owing to the bad milling qualities of the White Transparent, which made it compulsory to grind it together with a certain amount of Bourbon. But frequent single tests of the three varieties proved that even in normal dry seasons the White Transparent is a 'slow ripener' and of inferior sucrose contents to the Bourbon. In a very favourable season like 1903, however, it surpassed the Bourbon in this respect in April and May.

The reverse appears to be the case with D. 95, which reaches maturity earlier than the Bourbon, surpassing it always in sucrose contents. At several times, however, a deterioration in sucrose was noticed when once maturity was attained. D. 95 and White Transparent contain much less glucose than the Bourbon.

Thus, on March 1, 1901, the juice from the Bourbon contained 1·58 ℔. sugar per gallon, the White Transparent only 1·29 ℔., but D. 95, 1·96 ℔., a value never noticed again during that crop. Two months later, on May 7, the Bourbon contained 1·70 ℔., the White Transparent had risen to 1·90 ℔., but D. 95 had retrograded to 1·68 ℔. sucrose per gallon.

Again in 1902, on February 21, the White Transparent indicated only 1·27 ℔., as against 1·50 ℔. for the Bourbon. On April 4, we had 1·69 for Bourbon, 1·58 for White Transparent, and 1·79 for D. 95. On May 4, the Bourbon contained 1·77 ℔., but the White Transparent had risen to 1·92. In the favourable dry season of 1903 Bourbon started on February 26 with 1·69 ℔. sucrose per gallon and White Transparent with 1·56. On May 6, we find 1·88 ℔. for Bourbon, and 1·74 for White Transparent. D. 95 standing at 1·75 ℔., which was the richest sample noticed for this cane in 1903. In the unfavourable season of 1904 neither Bourbon nor White Transparent reached maturity. On March 9, the Bourbon indicated 1·62 ℔. sucrose, but the White Transparent only 1·29. D. 95, however, contained 1·73 ℔. sucrose per gallon.

After the rains in the beginning of April a retrogression in sucrose contents had already set in, for the Bourbon contained only 1·55 ℔ ; White Transparent, 1·45 ; and D. 95, 1·67 ℔.

All samples examined were taken from the mill juice as obtained in the factory, which explains that not so many could be taken as would have been desirable. For the grinding of the White Transparent canes unmixed with other canes was avoided as much as possible, not only on account of the difficulty to keep up a regular feed of the mills but also on account of the poor quality of the megass as fuel.

Thus, there are three serious drawbacks preventing the White Transparent from being a successful competitor with the Bourbon, viz., poor sugar contents during the earlier period of the grinding season, difficulty in milling, and poor quality of the megass as fuel.

The promising seedling D. 95 is free from these drawbacks.

It is only fair to state that another Usine of the Trinidad Estates Co., 'Caroni,' succeeded in overcoming the difficulty experienced in milling the White Transparent with the help of a cane slicer and double crushing, and the satisfactory extraction of 72·5 per cent. from the weight of the cane was secured. Maceration of the megass was used.

The question, which cane is to replace the Bourbon where the latter has failed, is a very difficult one, for I believe the majority of our planters still share the opinion expressed two years ago in Demerara, that so far no seedling cane has been grown which, in all-round good qualities, is equal to the Bourbon. At the same time, nobody will deny that the seedling canes have special merits peculiar to them, as is fully shown in the results published by the investigators connected with the Imperial Department of Agriculture.

ANALYSIS OF JUICE
FROM WHITE TRANSPARENT AND D. 95 COMPARED WITH BOURBON GROUND AT THE SAME PERIOD.

Date.	Bourbon.			White Transparent.			D. 95.		
	Beaumé at 85°.	Sugar. Pounds per gallon.	Glucose per cent.	Beaumé at 85°.	Sugar. Pounds per gallon.	Glucose per cent.	Beaumé. at 85°.	Sugar. Pounds per gallon.	Glucose per cent.
1901.									
March 1 ...	9·1	1·58	1·65	7·8	1·29	1·77	10·5	1·96	1·16
April 10 ...	9·2	1·61	1·54	...	...	...	8·3	1·47	0·94
„ 26 ...	9·7	1·69	1·51	...	...	...	...	over 1·81	ripe. 0·70
May 7 ..	9·7	1·70	1·42	10·2	1·90	0·65	..	1·68	0·72
1902.									
February 21	8·7	1·50	1·69	7·6	1·27	1·25	...	...	...
March 14 ...	9·3	1·62	1·45	8·5	1·42	1·51	9·0	1·62	0·80
April 4 ...	9·6	1·69	1·29	9·0	1·58	1·50	10·0	1·79	0·62
May 2 ...	9·9	1·78	1·10	9·6	1·83	0·40	9·7	1·76	...
„ 4 ...	9·9	1·77	1·17	10·4	1·92	0·90	...	...	...
1903.									
February 26	9·6	1·69	1·35	8·9	1·56	1·16	...	...	...
March 13 ...	9·5	1·67	1·34	...	...	...	8·8	1·54	1·25
April 20 ...	9·5	1·72	1·35	...	...	...	9·4	1·70	1·13
„ 29 ...	...	1·72	1·54	...	...	...	9·3	1·69	0·70
May 6 ...	9·9	1·88	1·07	9·6	1·74	0·90	9·6	1·75	0·97
„ 26 ...	9·7	1·75	0·87	...	...	...	10·6	1·95	0·45
1904.									
March 9 ...	9·2	1·62	1·40	7·9	1·29	1·72	10·1	1·73	...
April 18 ...	8·7	1·55	1·47	8·4	1·45	...	2·5	1·67	1·22
May 14 ...	8·8	1·49	1·40	8·2	1·46	..	...	...	...

RETURN

IN BOURBON, WHITE TRANSPARENT AND D. 95 IN 1904.

	Bourbon.		White Transparent.		D. 95.	
	Acres cut.	Tons cane per acre.	Acres cut.	Tons cane per acre.	Acres cut.	Tons cane per acre.
Section A.						
Plant Canes	...	...	214	30·52	53	32·85
1st. Ratoons	25	9·25	287	20·73	42	21·27
2nd. Ratoons... ...	151	17·53	106	14·36	114	20·90
Total	176	...	607	...	209	...
True average ...	...	16·35	...	23·07	...	24·00
Section B.						
Plants	30	24·93	77	25·40	...	...
1st. Ratoons	55	20·23	32	16·38	...	...
2nd. Ratoons... ...	148	14·27	...	...	...	...
Total	233	...	109	...	...	...
True average ...	...	17·05	...	22·75	...	...
Section C.						
Plants	64	19·25	97	22·64	...	...
1st. Ratoons	28	15·33	88	18·40	16	19·10
2nd. Ratoons... ...	102	13·55	34	17·63	...	...
Total	194	...	219	...	16	...
True average ...	...	15·68	...	20·15	...	...

RECAPITULATION (TONS CANE PER ACRE).

	Plants.	1st. Ratoons.	2nd. Ratoons.	Average actual.	Acres cut.
Bourbon	21·05	16·42	15·34	16·43	604
White Transparent	27·53	19·88	15·15	22·35	935
D. 95	32·85	20·68	20·88	23·65	225

DISCUSSION.

The President: In connexion with sugar-cane experiments we have had presented to us this morning in a very summarized form results that have taken a considerable amount of time and thought on the part of the workers engaged therein, and it must be a source of very great satisfaction to them to find that we have made substantial progress, not merely in regard to the raising of seedling canes, but in connexion with the application of manures. As the result of the work which is going on, I am not without hope that we shall be able to place the sugar industry in the West Indies in a thoroughly good position. I think we may regard the experiments now carried on in the West Indies as having reached as high a standard as obtains in any part of the world. We do not propose to rest on our oars in this matter but to go on in the careful and deliberate manner as we have in the past, and to present year by year such records as I think planters will be able to adapt to their own requirements, and to grow not only richer canes resistant to the attacks of disease, but to produce a larger amount of sugar per acre at probably a smaller cost.

I should like to bring before your notice a paper which I have had printed for circulation at the Conference, giving the results of the cultivation of cane seedlings on Diamond estate in British Guiana. Experiments were carried on for four years with Bourbon and seedling canes, and Mr. Fleming, who has contributed the information, has found that in 1901 the seedlings were 29 per cent. better than the Bourbon; in 1902, 21 per cent.; in 1903, 14 per cent.; and in 1904, 31 per cent.

Seedling canes have proved of very considerable value to planters: whether they will prove so in every case, we cannot say; we must leave it to the planters to adopt in every case that which they find to be more remunerative.

SEEDLING CANES AT DIAMOND PLANTATION, BRITISH GUIANA.

The following interesting information in regard to the experimental cultivation of seedling canes at Diamond plantation is taken from a letter received from the Manager, Mr. John M. Fleming, dated March 24 last, which was published in the *Agricultural News*, Vol. III, p. 180. Later information, relating to the year 1904, was contained in a letter dated December 14, 1904:—

'For the short grinding just completed here last week, 605 acres of Bourbon and 104 acres of B. 208 were reaped. All of these canes suffered from a deficiency of rain in January to the middle of March, when they were young, and later on, from the middle of April to the middle of July, from excessive wet. This made them stunted, and in the arrowing season almost every individual Bourbon cane flowered: B. 208 arrowed more than in the previous year, but still not nearly to the same extent as Bourbon. It exhibits, however, a marked tendency to sprout at the eyes after the arrowing period.

'The Bourbon cane yielded an average of 1·91 tons sugar per acre: the B. 208, 3 tons per acre, or about 57 per cent. more. This is a very much greater difference than I have hitherto observed, and is due to the stunted crop of Bourbon. It is an interesting record, but by no means expresses the comparative values of the two varieties in a year more suited to the Bourbon. The quality of cane juice from each was excellent, and far better than is usual in Demerara.

'The following table gives the results of growing Bourbon and seedlings, for the years 1901, 1902, 1903, and 1904 on this plantation:—

	1901			1902		
	Acres.	Tons.	Aver.	Acres.	Tons.	Aver.
Bourbon	2,912·208	6,735	2·31	2,791·062	6,464	2·31
Seedlings	1,073·082	3,215	2·99	1,317·277	3,706	2·81
Total ...	3,985·290	9,950	2·49	4,109·039	10,170	2·47
Seedlings better by	29 per cent.			21 per cent.		

	1903			1904		
	Acres.	Tons.	Aver.	Acres.	Tons.	Aver.
Bourbon	2,895·067	7,194	2·48	2,699·072	6,050	2·24
Seedlings	1,879·267	5,331	2 83	1,882·047	5,550	2·95
Total ...	4,775·034	12,525	2·62	4,581·119	11,600	2·53
Seedlings better by	14 per cent.			31 per cent.		

The following is a further expression of opinion from Mr. Fleming in regard to cane B. 208:—

'B. 208 is in my opinion the best cane you have given us so far. I have just finished reaping nearly 100 acres of it, and notwithstanding the fact that after they were planted in January 1903 they encountered a severe drought and some months later an exceptionally heavy rainy season, and were in consequence not a heavy crop, they were still a long way better than Bourbons grown under similar conditions. An objectionable feature of this variety is a marked tendency to sprout at the eyes after the arrowing season, or when its growth has from

any cause been temporarily checked. A very strong point in its favour is that in every trial I have made of it I have invariably found the juice of excellent quality.'

With regard to the results for 1904, Mr. Fleming writes :—

'Taken with the results for the three preceding years, this goes a long way to prove that in the propagation of cane from seed lies a ready means of obtaining varieties superior to the Bourbon, hitherto generally grown in Demerara.'

The Hon. B. HOWELL JONES (British Guiana): There is one question in connexion with the papers read this morning on the results of recent experiments with seedling canes, on which I should like to have an expression of opinion, and that is the quality of the canes for manufacturing purposes. It is a question of great importance to us in British Guiana whether the megass from certain seedling canes will produce a sufficient amount of steam to drive our works. Our experience with many of the seedling varieties is that the megass when put in the furnaces damps down and refuses to burn. That has been attributed to the furnaces, but experience shows otherwise. The question is now receiving a good deal of attention from Professor Harrison, and I had hoped in attending this Conference to have heard some expression of opinion on the matter.

Professor D'ALBUQUERQUE explained that in the experiments carried out at Barbados with a view of determining whether or not a particular variety of cane was a good cane, its milling qualities were always inquired into and determined.

Dr. FRANCIS WATTS (Leeward Islands): In muscovado factories very little precise information is obtainable on this point; but the megass from the Bourbon cane is considered more suitable for furnace work than any of the varieties.

Mr. E. W. F. ENGLISH (British Guiana): The Sugar-cane Experiments Committee of the Board of Agriculture requested me to make inquiries as to the milling properties and qualities of megass of seedling canes, but the returns sent in render it very difficult to come to any conclusions, the results being so widely divergent.

The Hon. S. HENDERSON (Trinidad): In this country considerable difficulty was found in the milling of the canes, the varieties being White Transparent and a few seedlings. That difficulty was shown to be due to single-crushing mills. The fuel question still remains a very vexed one. The furnaces in use may be responsible for it.

The PRESIDENT: Professor Harrison in a recent report suggests that the difficulty might be overcome by crushing different varieties of canes together and by using crushers before the rollers.

ERRATA.

Page 80, line 27, *for* natural *read* native.
,, 83, lines 21 and 25, *for* cabouse *read* cahouse.
,, 85, line 14 from bottom, *for* Nima *read* Mina.
,, 86, ,, 13, *for* gymnopthalma *read* gymnophthalma.
,, ,, ,, 20, ,, nibs *read* webs.
,, ,, ,, 32, ,, Cartharopega *read* Cartharopeza.
,, 88, ,, 11 from bottom, *for* Ortalda *read* Ortalida.
,, 89, ,, 13, *for* branches *read* beaches.
,, 90, ,, 17 from bottom, *for* black-billed *read* black-bellied.
,, ,, ,, 12 ,, ,, ,, Hiniantopus *read* Himantopus.
,, ,, ,, 10 ,, ,, ,, Dowitchu *read* Dowitcher.
,, ,, ,, 2 ,, ,, ,, Chirps *read* Chips.
,, 92, ,, 15, *for* Bridgway *read* Ridgway.
,, 364, in last column of table, *insert* decimal points after first figure where omitted.

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